Statewide Aerial Imagery Program

Presentation to the Michigan GIS User's Group

February 7, 2013, 1:00pm

Presented By:

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Senior Project Manager

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Director, Strategic Accounts

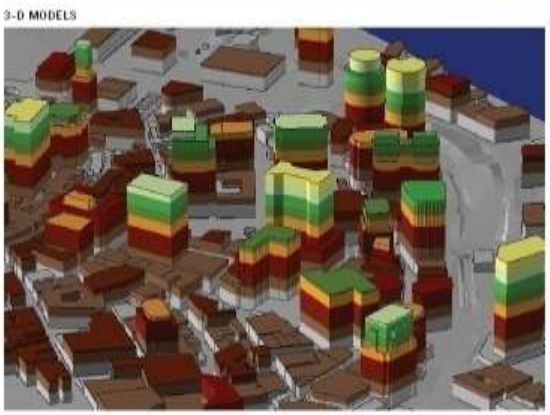
Presentation Topics

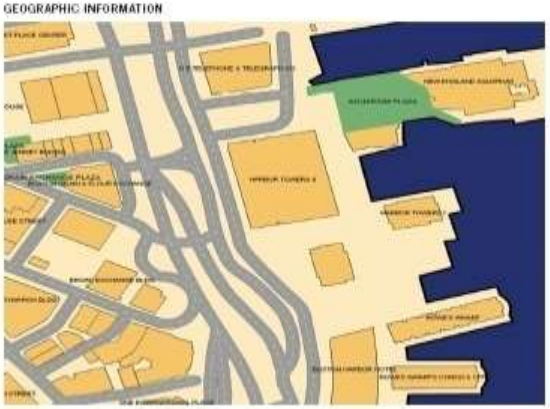
- Introduction
- Sanborn Profile
- Imagery Program History
- Orthoimagery Offerings
- Break
- LiDAR Offerings
- Data as a Service
- Pricing
- How to Order

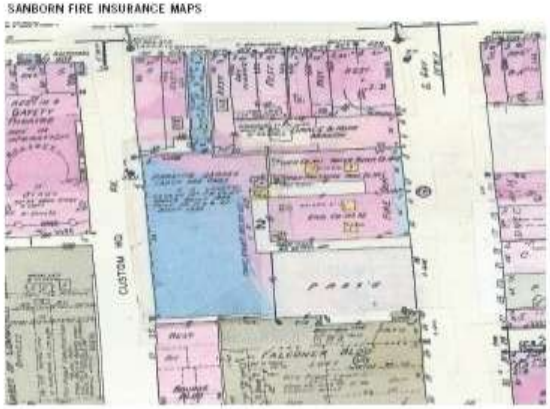
Sanborn – Leader Since 1866

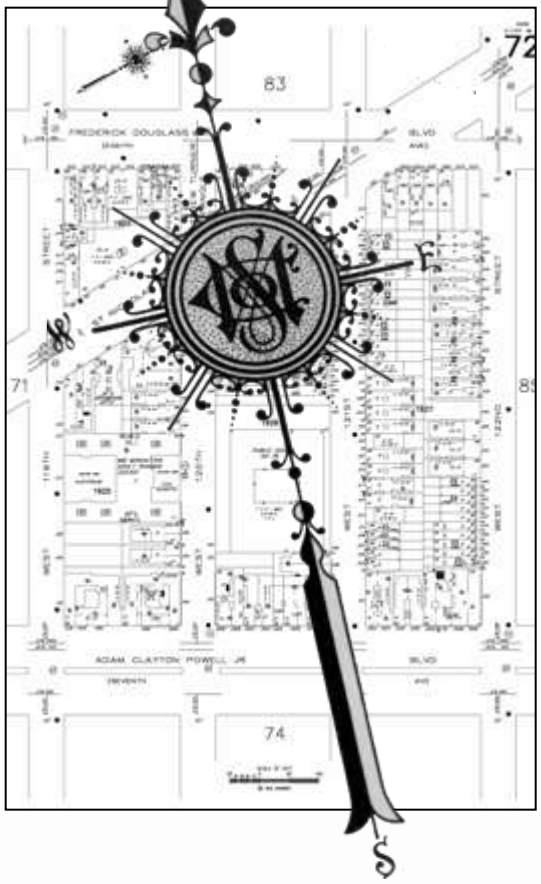
Sanborn Maps™

- Extensive mapping & GIS collection with over 12,000 municipalities nationwide
- Digital Photogrammetric Mapping since 1979



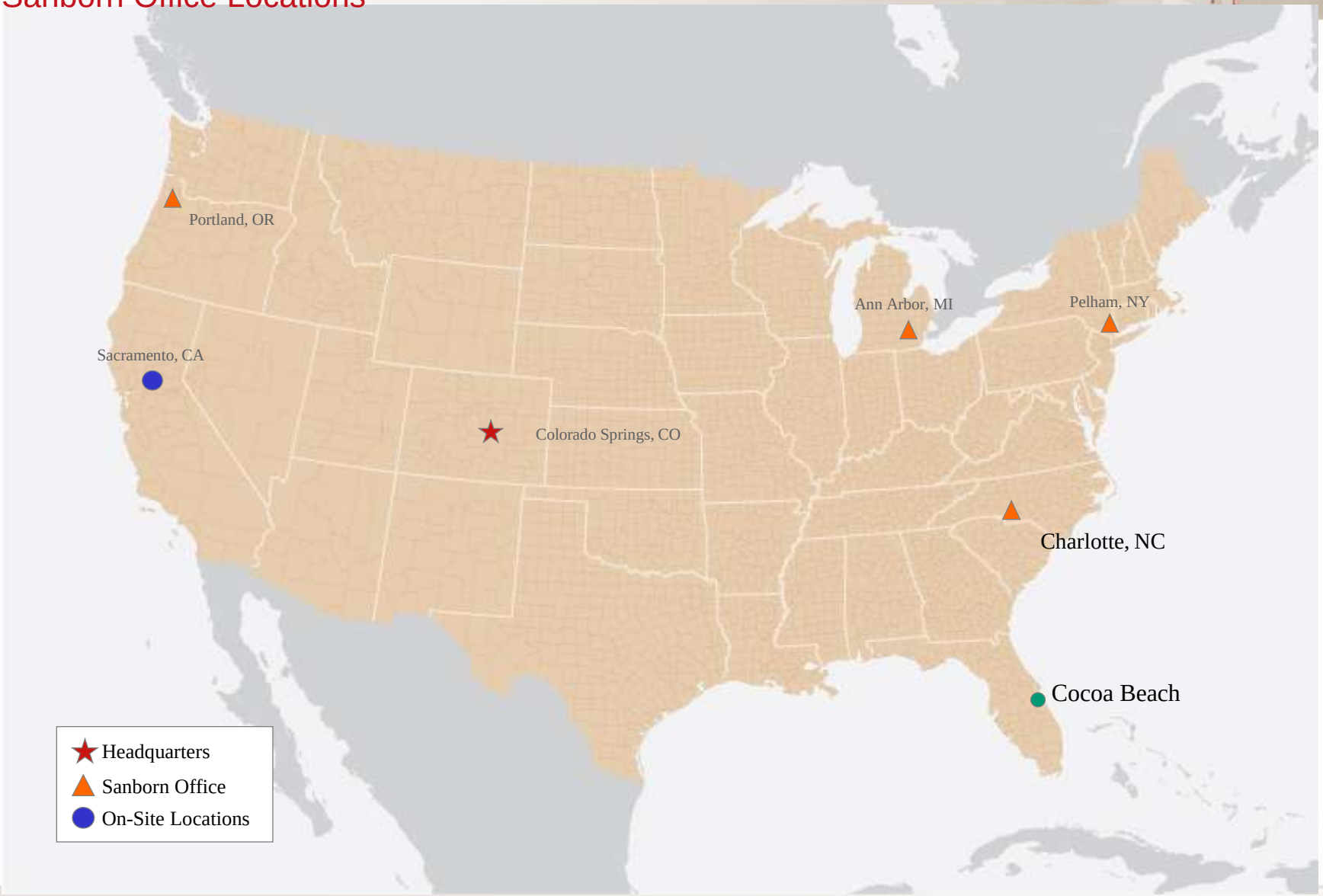






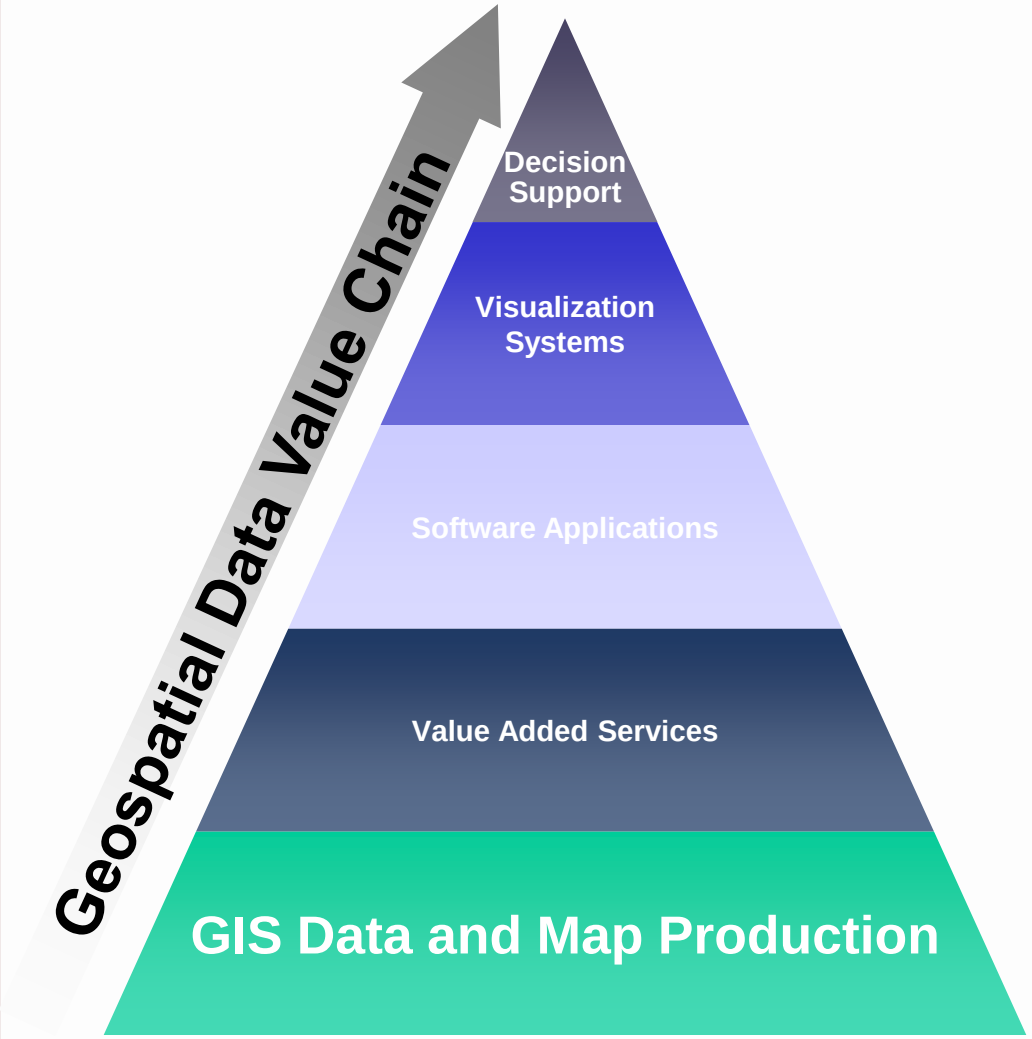
Overview

Sanborn Office Locations



Comprehensive Solutions

- **Decision Support Systems**
  - Wildfire Management
  - Forestry and Ecosystem Management
  - Emergency Response
- **Visualization Systems**
  - 2D
  - 3D
- **Software Applications**
  - GIS Software Development (Enterprise/Desktop/Web)
  - Portals and Distribution Tools
- **Value-Added Services**
  - Consulting
  - Land use and land cover analyses
  - Change detection
  - Other imagery analysis services
- **Mapping & Remote-Sensed Services**
  - LiDAR, Digital Orthoimagery, Photogrammetric, Topographical Maps

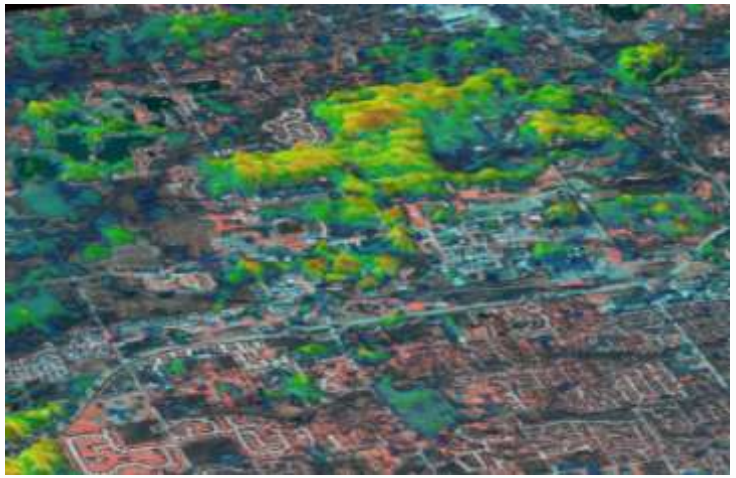


Sanborn Company Profile

- Offices in 5 states
- 150 employees
- Services include:
  - Aerial Imagery
  - Aerial & Terrestrial LiDAR
  - Land Surveys
  - Digital Terrain Modeling
  - Planimetric/Topographic Maps
  - 3D Modeling and Simulation
  - Satellite Imagery
  - Remote Sensing
  - Parcel & Utility Conversion
  - GeoIT Services

Information Map Products

Fire Threat Models



Land Cover & Impervious Surface

Agricultural Assessment

Predictive Analysis – Drug Safe Locations

Qualifications: Relevant Experience on Programs in the Region

- Sanborn is presently the statewide imagery and mapping contractor for:
  - Commonwealth of Virginia (2006-2016)
  - State of New York (2008-2013)
  - State of Michigan (2013-2015, 2016, 2017)

- Prior Michigan projects completed for:
  - Oakland, Manistee, Grand Traverse, Hillsdale, Otsego, Wayne and Livingston Counties
  - City of Ann Arbor

- Imagery and LiDAR under federal contracts in:
  - New Hampshire, Vermont, Massachusetts, and Maine

- Sanborn understands regional challenges
  - Short window of opportunity between snow-free and leaf-on
  - Weather patterns
  - Sanborn's Ann Arbor office performing final QC of imagery

Project Management

- *Rigorously applied Project Management Institute model*

Primary Roles:

- Implement ISO 9001: 2008
- Regular status reports and project meetings
- Customer liaison to operations
- Project scope and schedule compliance
- Provide project work plan
- Implement use of P3E® Integrated Scheduling & Productivity Tracking System
- Implement Sharepoint Site
- Implement GeoServe

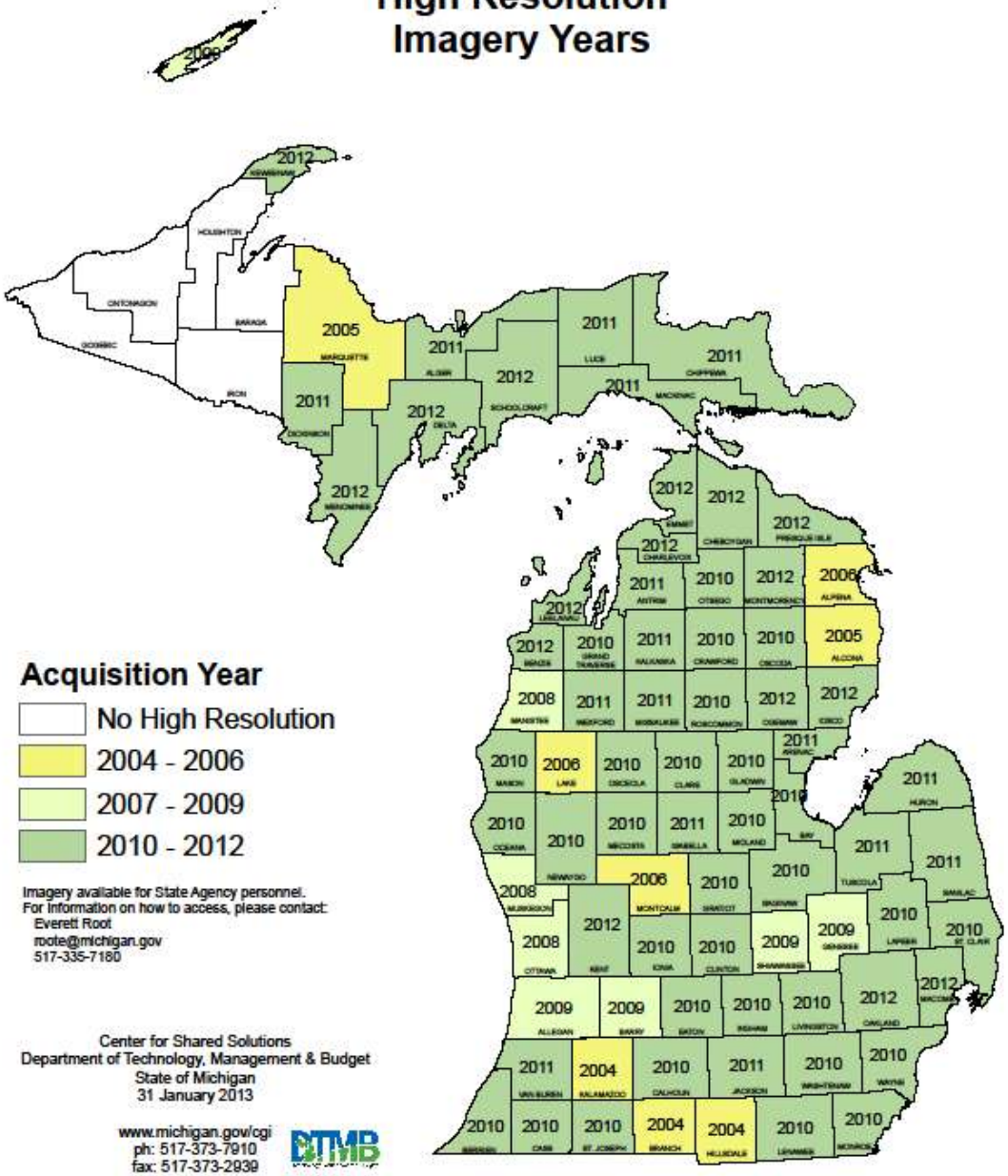
Krysia Sapeta

- Technical Base; Photogrammetry, Orthoimagery, Planimetric Update
- Over 20 years managing mapping programs
  - Project Management Professional (PMP)
  - Certified Photogrammetrist (CP)
  - GIS Professional (GISP)
- Recent Programs:
  - State Of Virginia
  - FL Department of Revenue (multi-year; Orthoimagery)
  - State of Kansas (Multi-year; FEMA LiDAR)
  - New York City (since 1997)
  - City of Colorado Springs (multi-year; Ortho, LiDAR, planimetric update)
  - LOJIC (orthoimagery, planimetric update, LiDAR)

Program History

Program History

State of Michigan
Center for Shared Solutions
High Resolution
Imagery Years



Acquisition Year

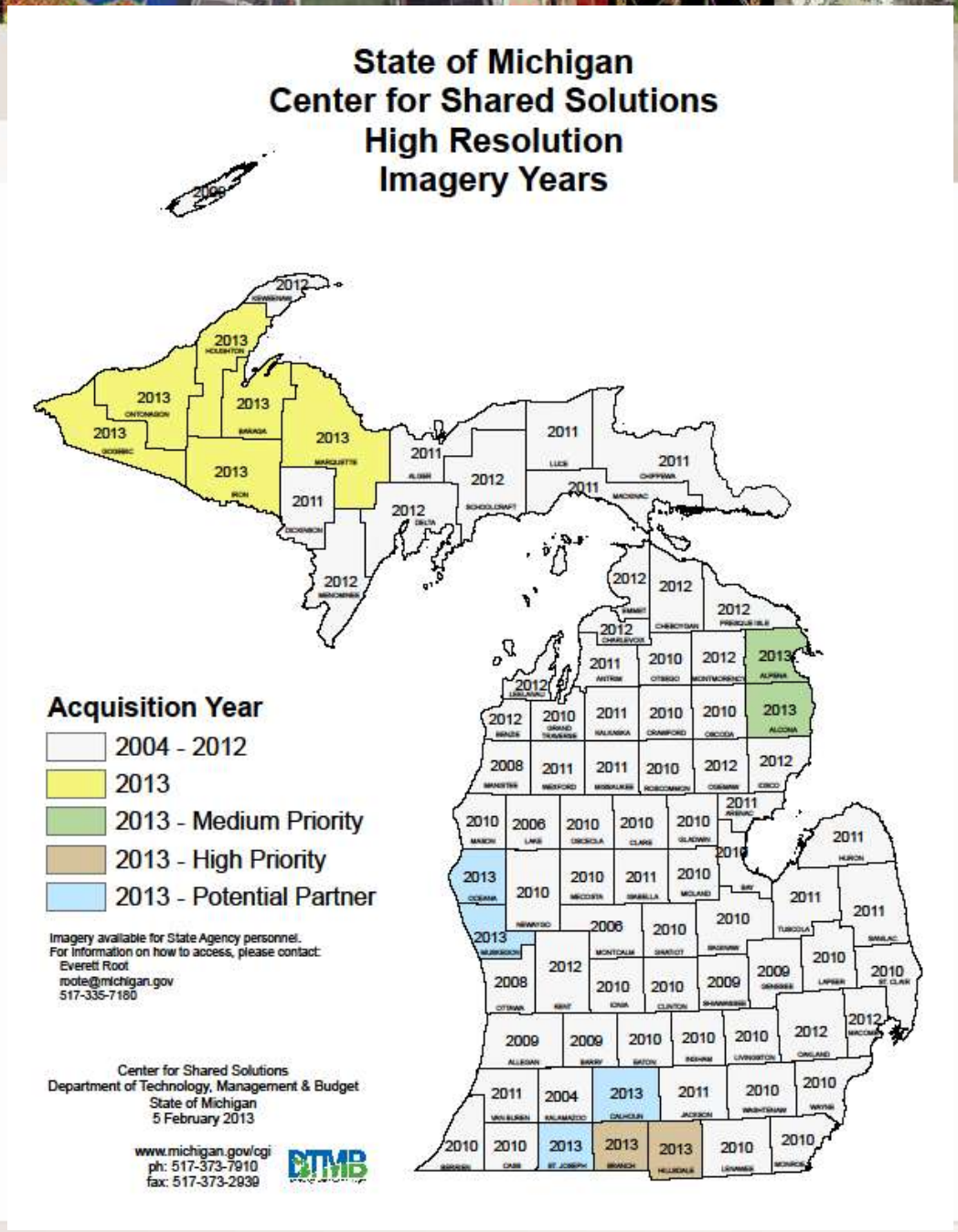
- No High Resolution
- 2004 - 2006
- 2007 - 2009
- 2010 - 2012

Imagery available for State Agency personnel.
For information on how to access, please contact:
Everett Root
rroote@michigan.gov
517-335-7180

Center for Shared Solutions
Department of Technology, Management & Budget
State of Michigan
31 January 2013

www.michigan.gov/cgi
ph: 517-373-7910
fax: 517-373-2939

2013 Tentative Flight Areas



Program Details

- Base contract of 3 years, plus 2 option years (2013-2015 base, 2016, 2017 options)
- Imagery, LiDAR, and DaaS
- Can be expanded to other geospatial services, and to meet specialized/custom needs and requirements
- SOM has sole rights to use the data in perpetuity
- Partnership opportunities
  - County
    - Funding from: Federal, COGs, Cities, Townships, Utilities, Tribes, etc.
- Data sharing – At the discretion of the partner

Feature Comparison

FEATURE	PREVIOUS	NEW
Public Domain	No	Partner discretion
Partner price base product	$28	$28
Accuracy specification	<6.67 feet @ 90% confidence NMAS standard	<3.8 feet @ 95% confidence NSSDA standard
Infra-Red (IR or 4th band)	Optional Buyup	Included
Digital Elevation Model	Optional Buyup	Included
6” GSD Buyup	Yes	Yes
3” GSD Buyup	No	Yes
Lidar	NA	Yes – 5 buyup options
AOI Contiguity discount	No	Yes – 16%-17.7%
Sub-County AOI	No	Yes

Program Offerings - Imagery

- Intent is to fly ~20% of State per year each spring, leaf-off, snow-free
- Base product is 12-inch pixel resolution
- Buy-up options for 6-inch and 3-inch high resolution areas (HRA's)
- Accuracy at all resolutions will be NSSDA 1"=100' @ 95% confidence = 3.8' absolute accuracy
- Radiometry will be 4-band, 8-bit per channel R/G/B/NIR
- Tiled deliverable (5000' x 5000'), GeoTIFF format
- Michigan State Plane Coordinate System, Appropriate Zone, North American Datum 1983(1986), Units of International Feet

Data Acquisition

Extensive *Sanborn-owned and partner-provided resources*

- Fixed-wing aircraft (9), total of (28) on team (Sanborn and Keystone)
  - Includes multi-engine and turbine-powered aircraft
- Digital Aerial Cameras (5), total of (11) on team
- LiDAR sensors (3), total of (4) on team
- ABGPS/IMU-equipped for accurate sensor position & orientation information

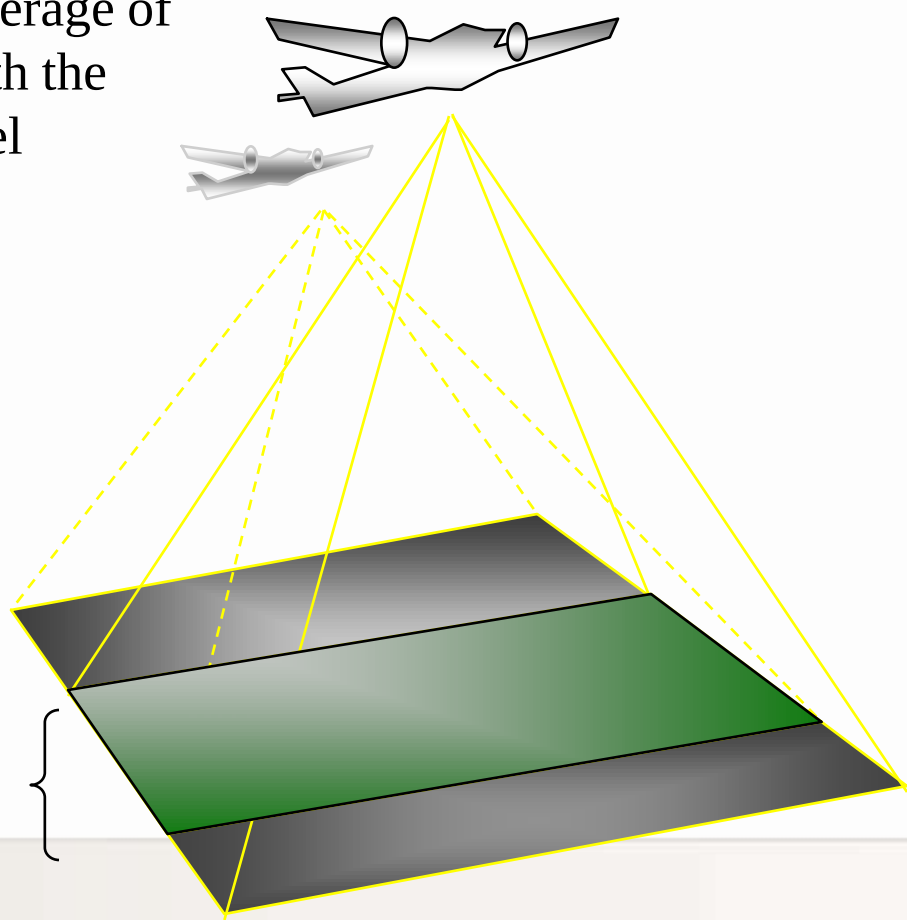
UltraCam Eagle - Mapping

- Proven technology from Vexcel family of cameras
  - Third generation of Vexcel System
  - Sanborn has owned and operated Vexcel cameras since 2004
  - Solid state, in-flight exchangeable storage. Higher reliability. Less ground time.
- Large format Metric Camera
  - Larger footprint then Vexcel UltraCam reduces flying time and risk without compromising quality/accuracy
- Improved technology=improved quality
  - 5.2 μm pixel size state-of-the art CCD technology lower signal to noise ratio

Stereoscopic Coverage

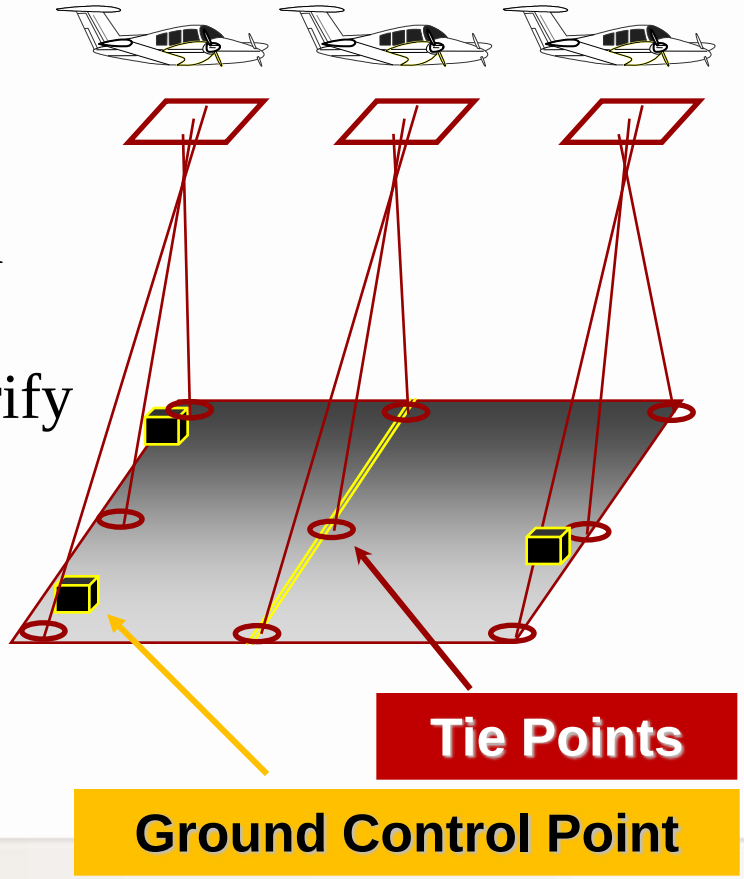
- Overlapping images provide 3D viewing (typically 60% forward lap/ 30% sidelap)

- Adjacent images having overlapping coverage of the ground are known as stereo pairs, with the overlapping area known as a stereo model

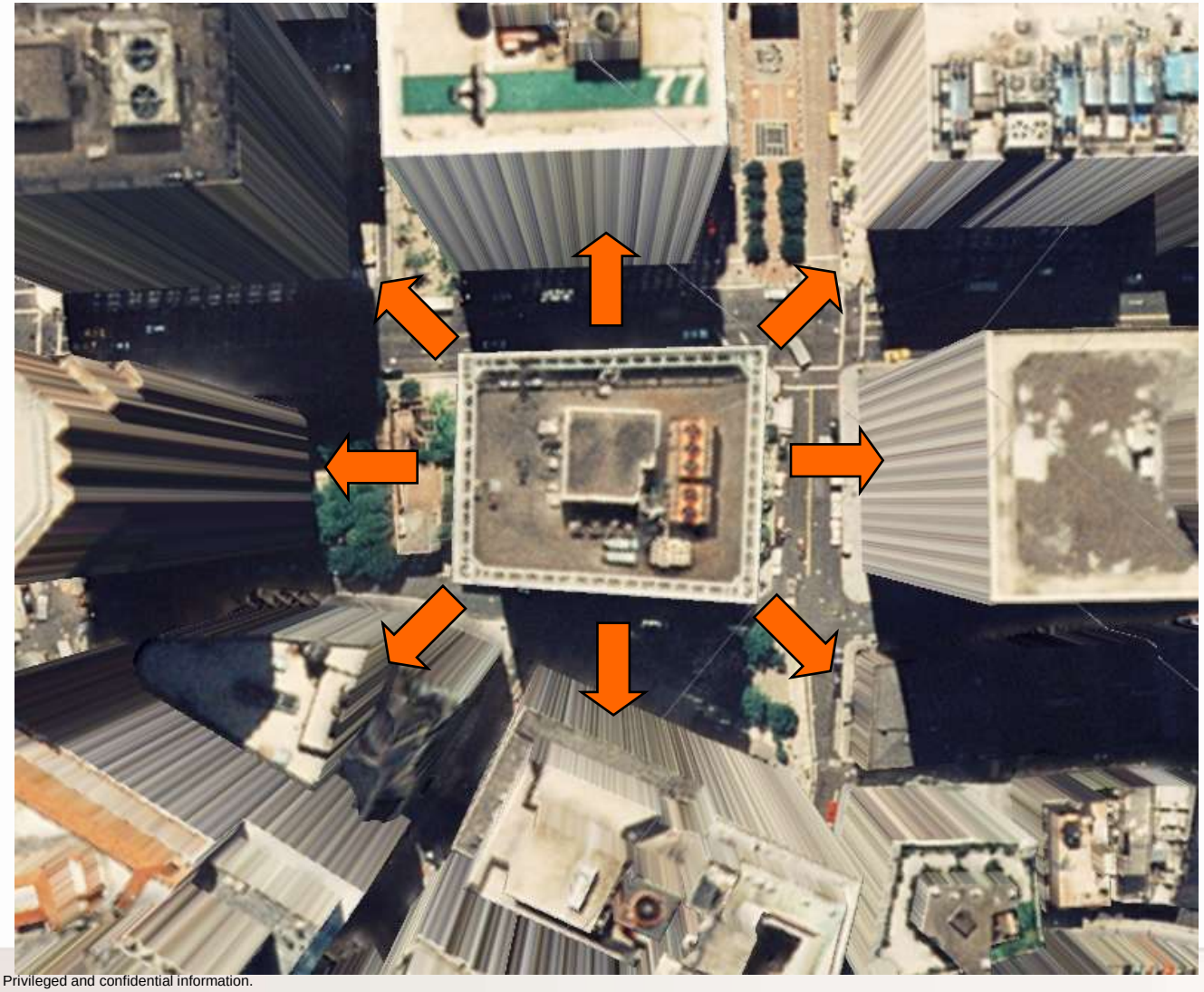


Aerial Triangulation

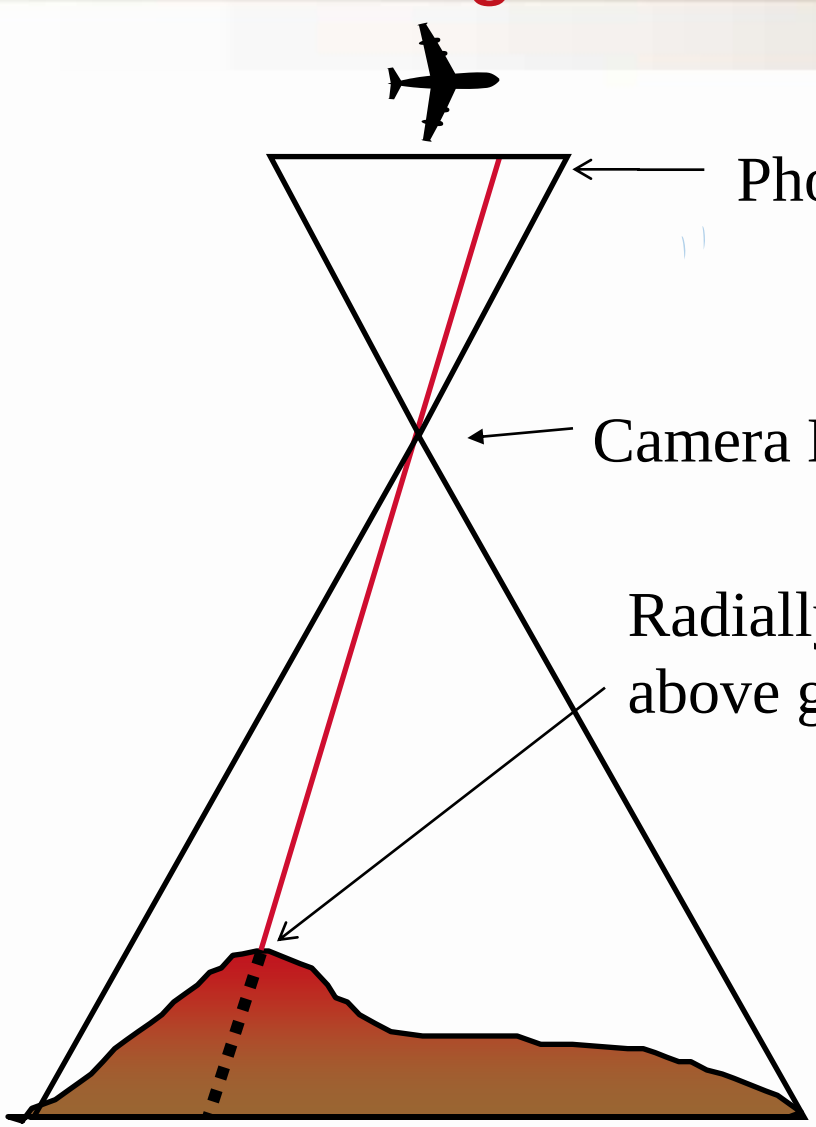
- Ties photo coordinates to real world through AGPS/IMU and ground control
- Locally-based land survey support by ***Surveying Solutions, Inc***. – largest survey firm in Michigan
- Forms the basis for the accuracy of all photogrammetric products
- Rigorous Analytical Aerial Triangulation
  - Least square adjustment
- Control points used as checkpoints to verify quality of the AT adjustment
- AT Report provided with residual values



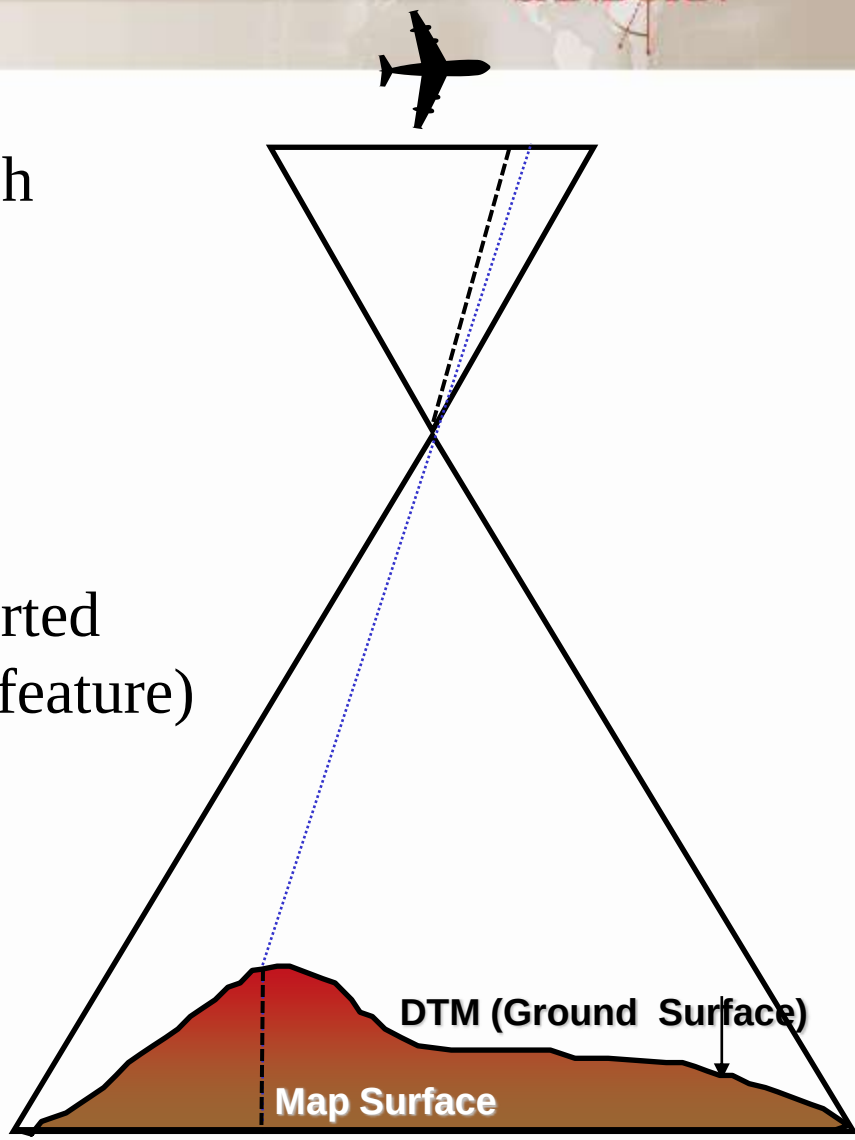
Radial Distortion



Standard Digital Orthophoto



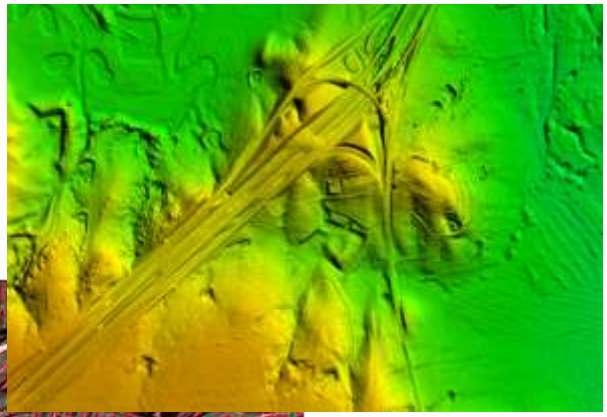
All above ground features displaced

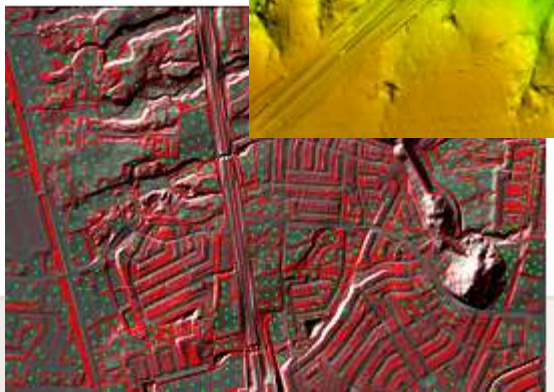


'Orthogonal' Correction using Ground Surface (DEM/DTM)

Digital Elevation Model (DEM)

- Sanborn is creating a new DEM in all areas where imagery is ordered
- If a partnering agency has a DEM/DTM available, Sanborn may opt to use and update/enhance it, or replace it as needed
- Suitable for ortho production only
- Enhancement necessary for contour products

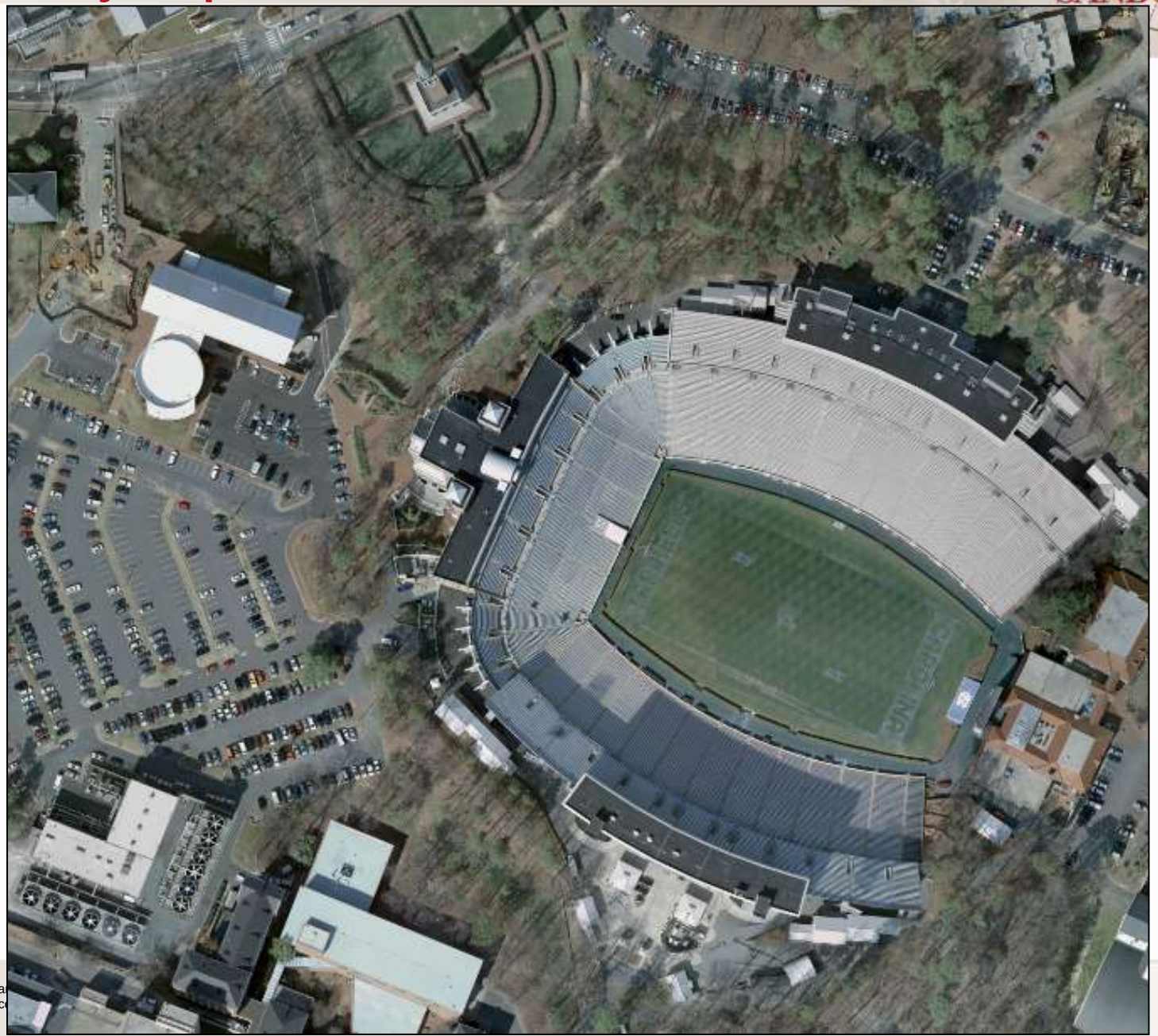




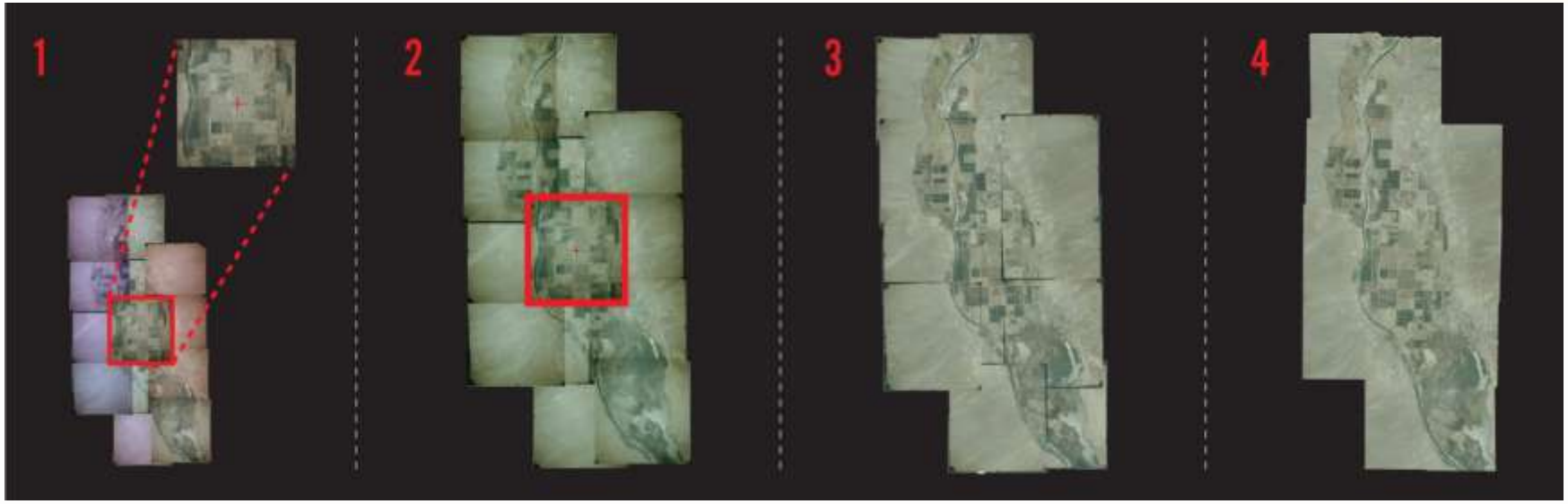
Primary Deliverable: 1’ Resolution

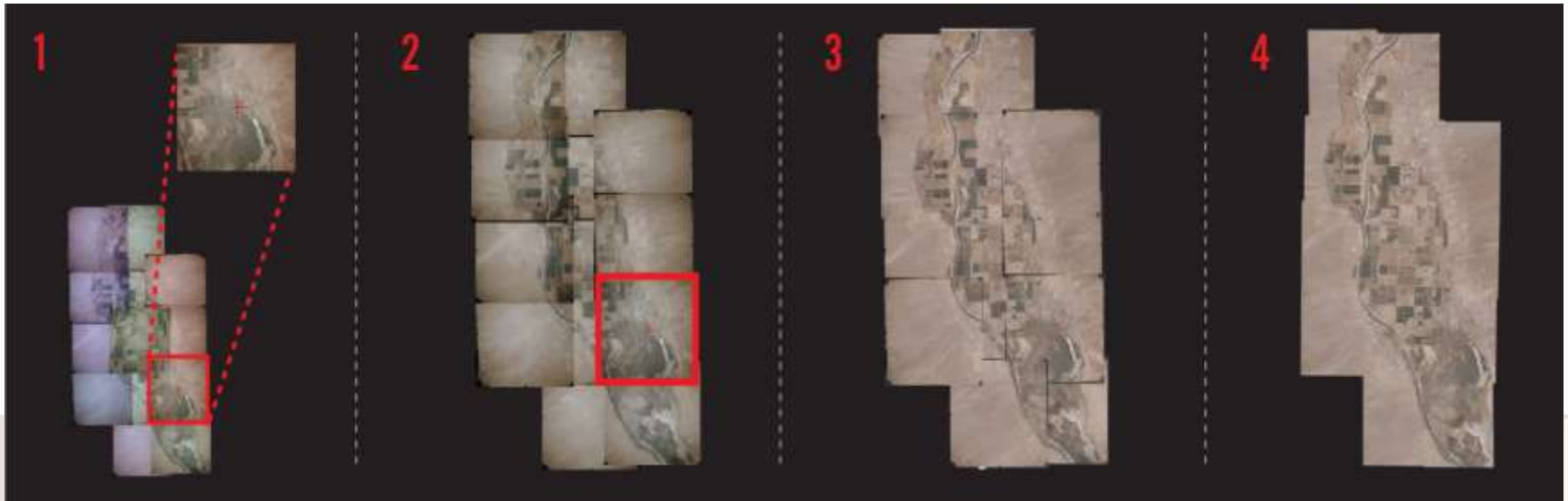
6” Buy-Up:

3” Buy-Up

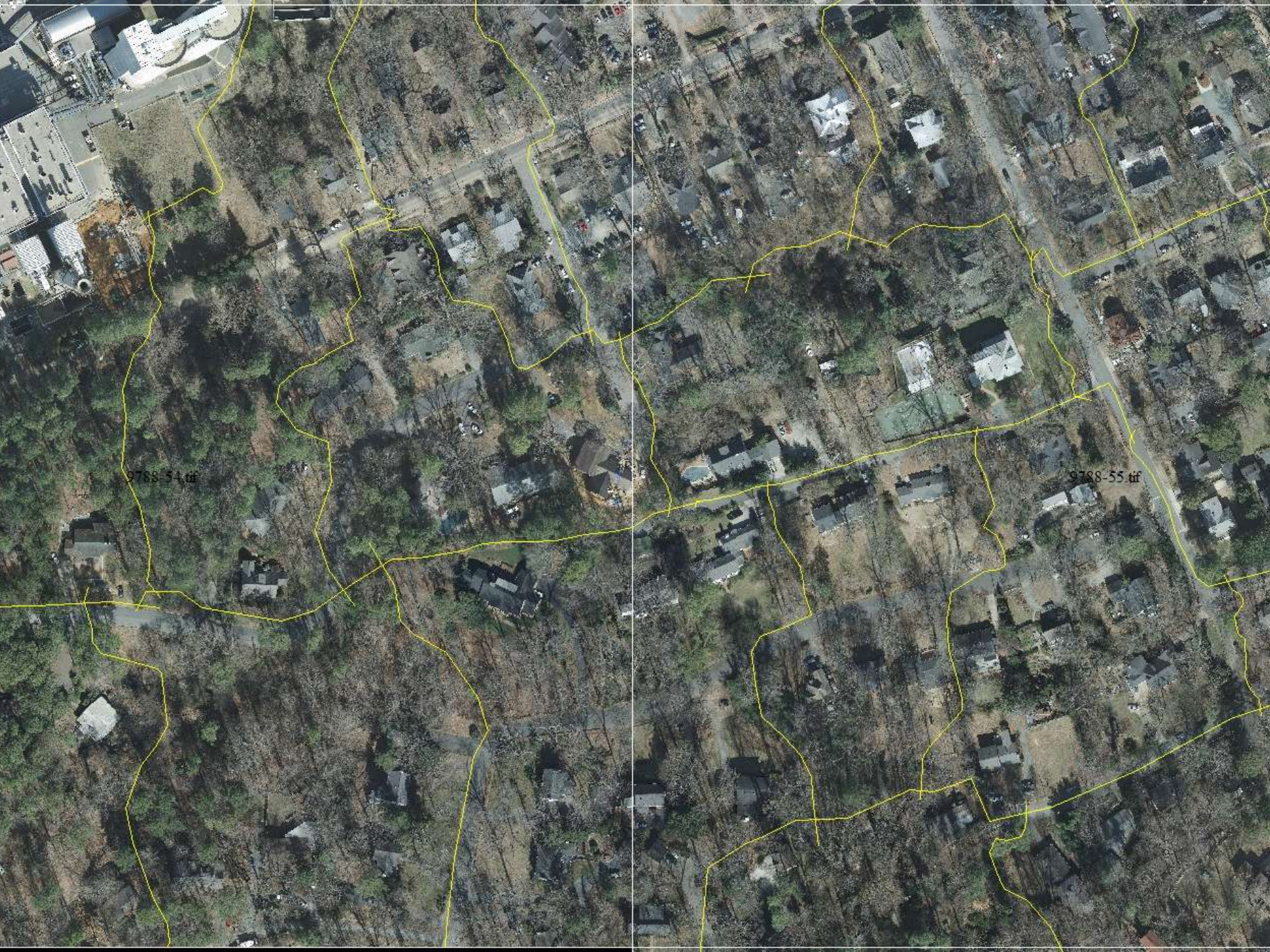


13. Seamless Mosaic (continued





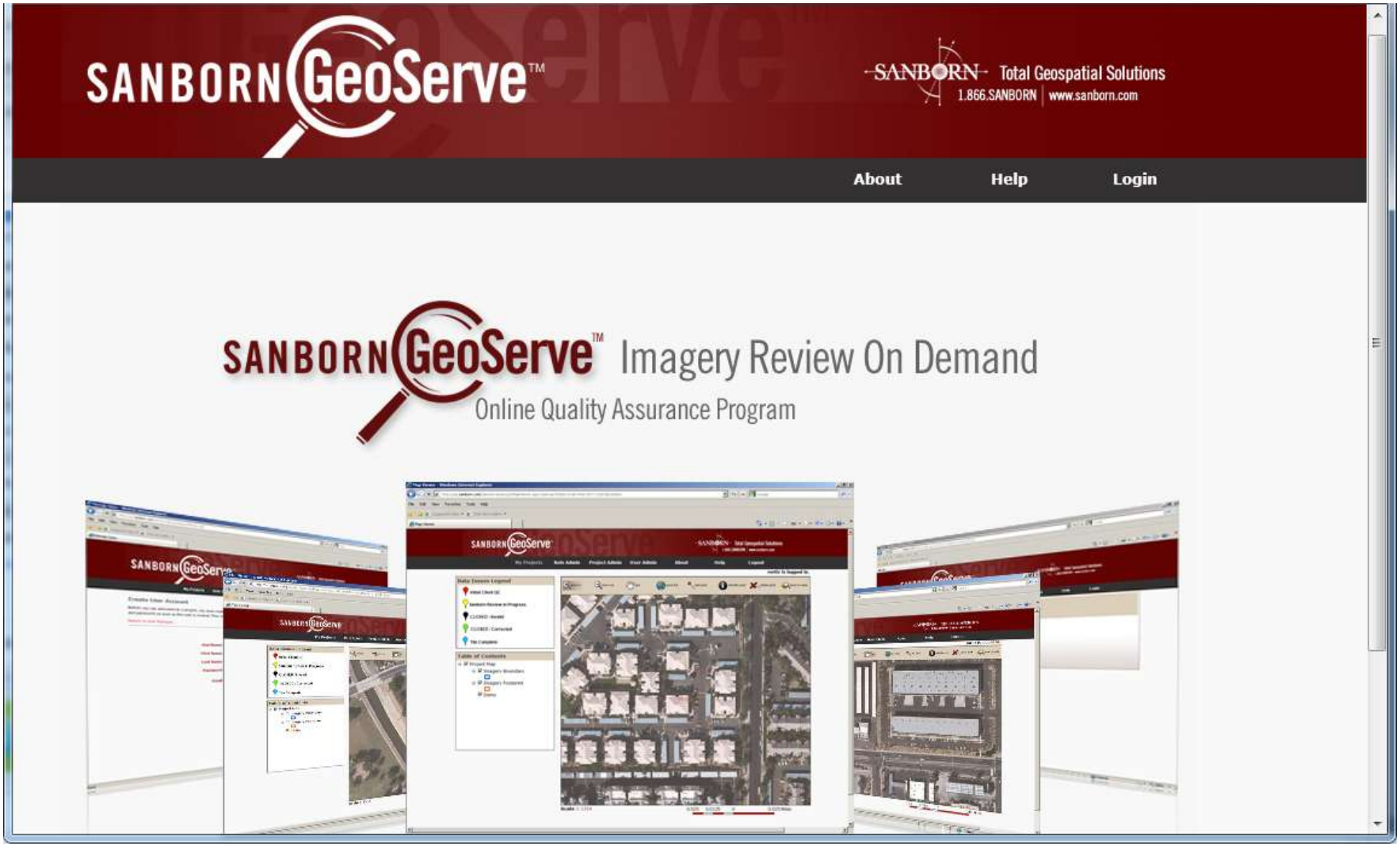
Seamless Mosaic (continued)


9788-54.tif
9788-55.tif

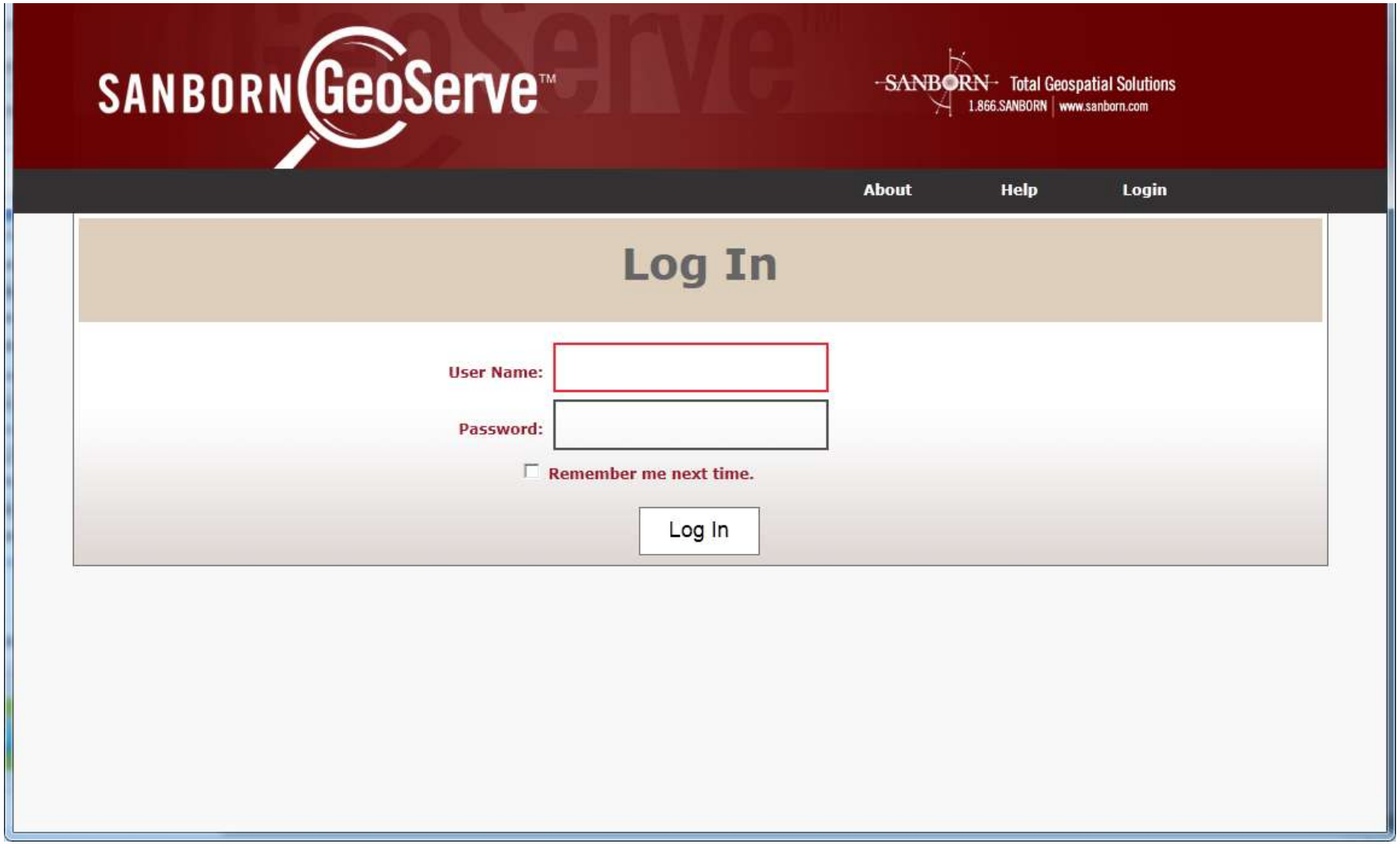
GeoServe – Editing in the Cloud

- Efficient Methodology for Orthoimagery Review
- Quality control of imagery via website interface
  - Login
  - Review data
  - Mark areas of concern
- Sanborn staff receive notifications on areas of concern
  - Corrections are made
  - Corrections posted
  - Issue responded to in the same interface

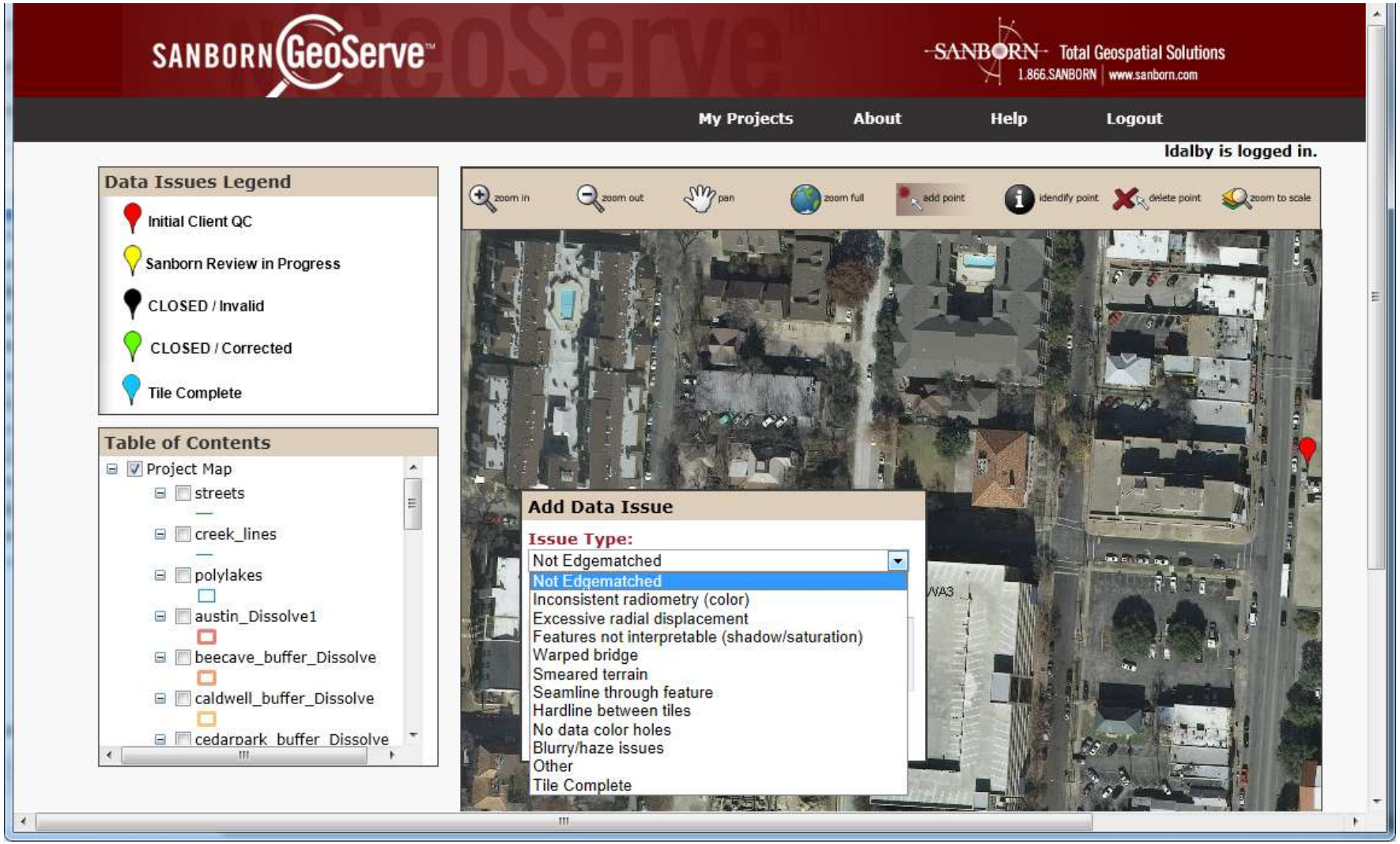
GeoServe Home Screen



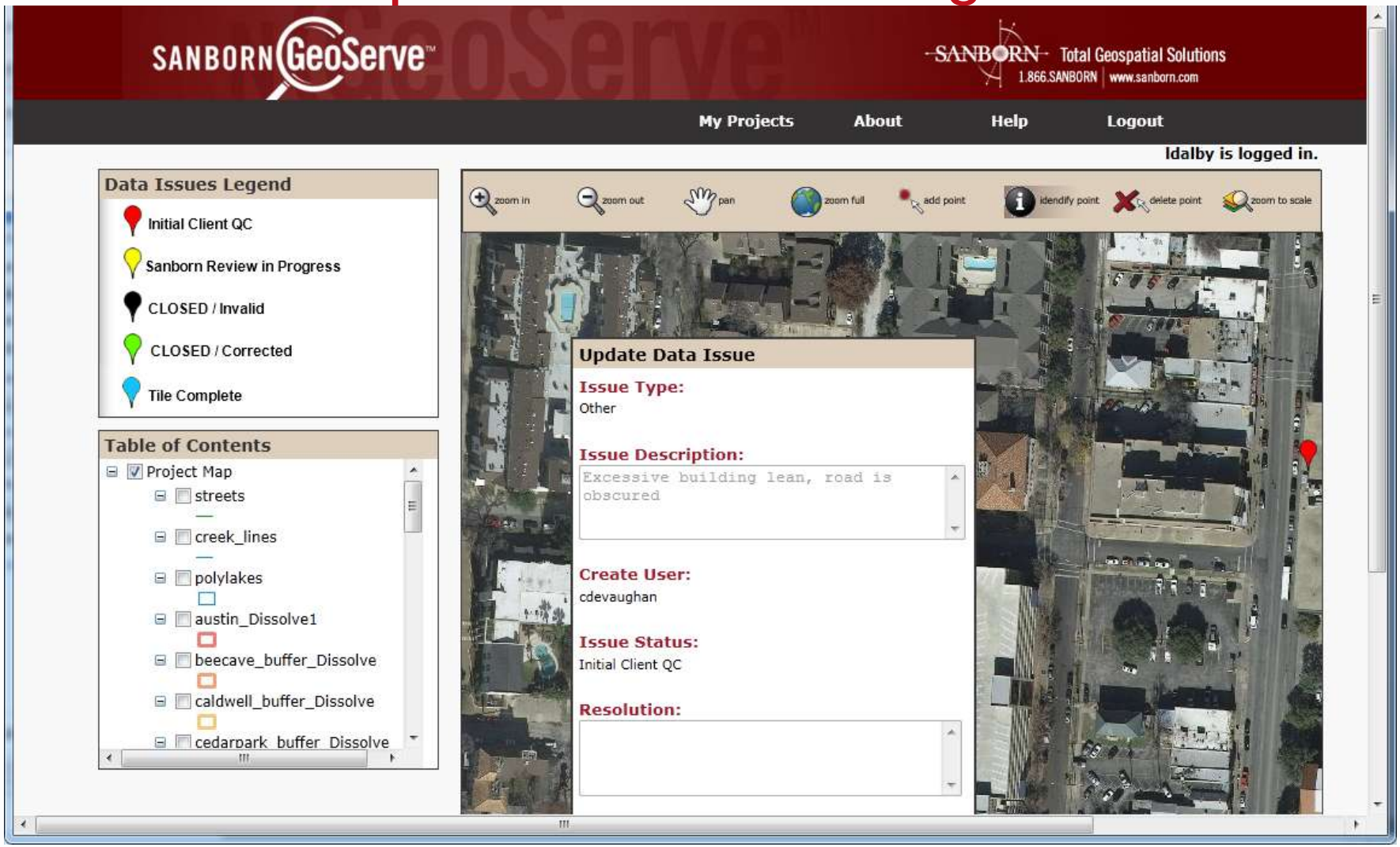
GeoServe - Login



Add Point & Select Data Issue

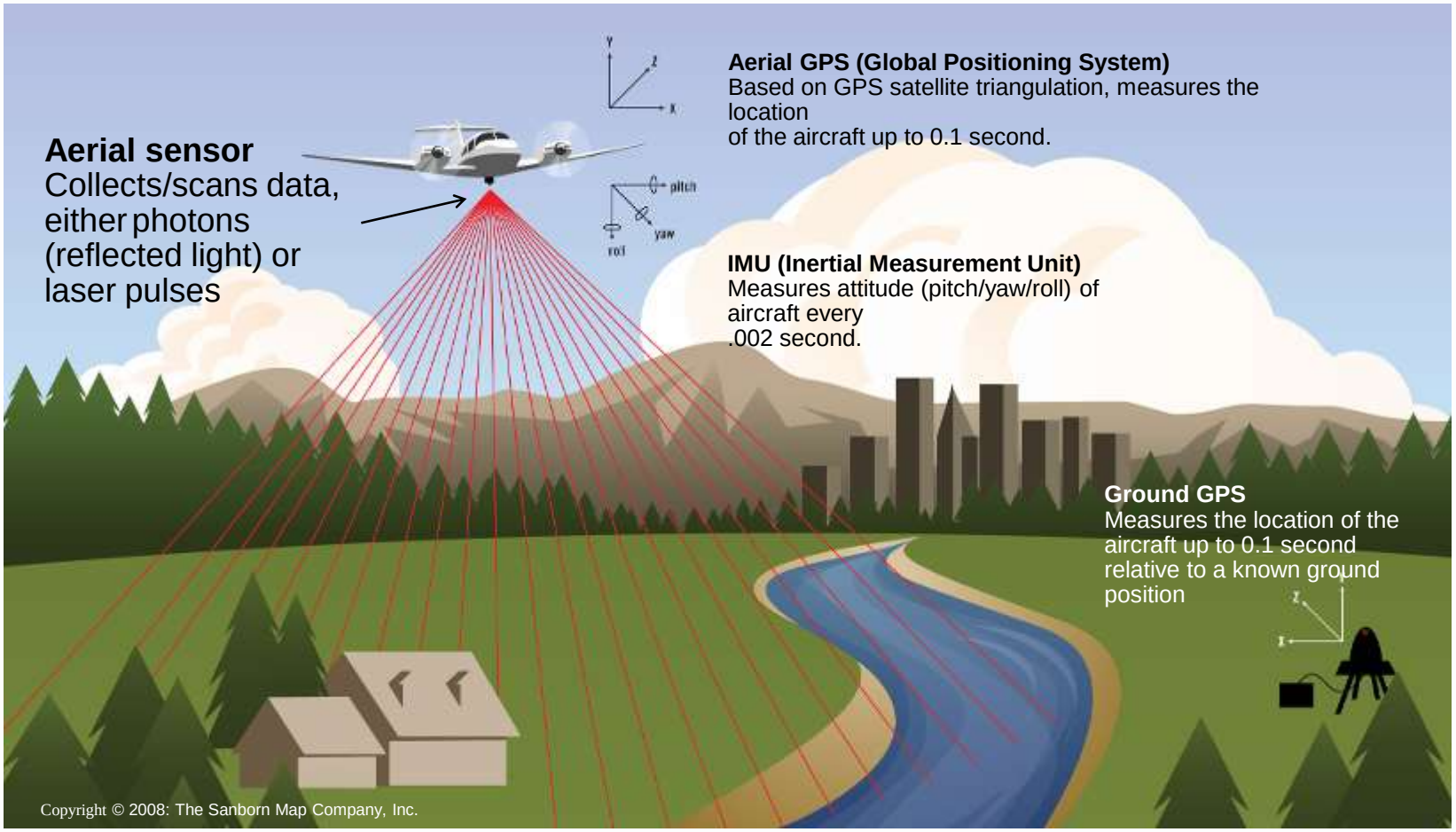


Additional Information Can Be Added
Creator is captured based on login



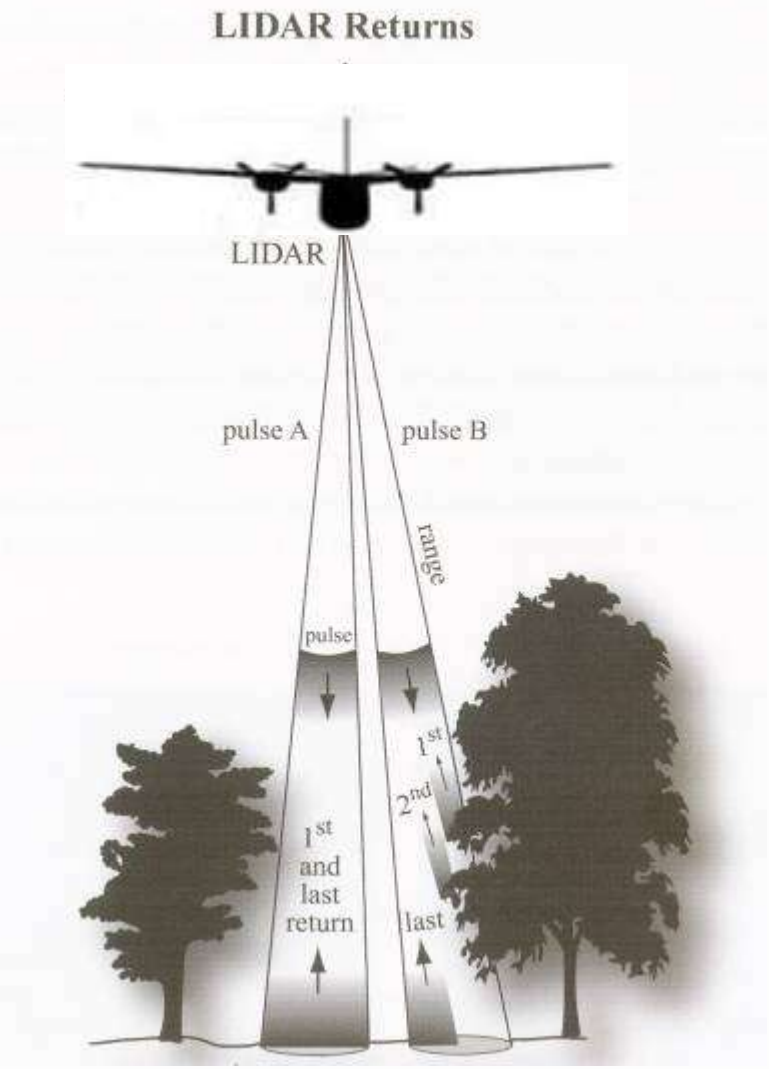
LiDAR: Light Detection and Ranging

What it is?



LiDAR the Basics

Multiple return data

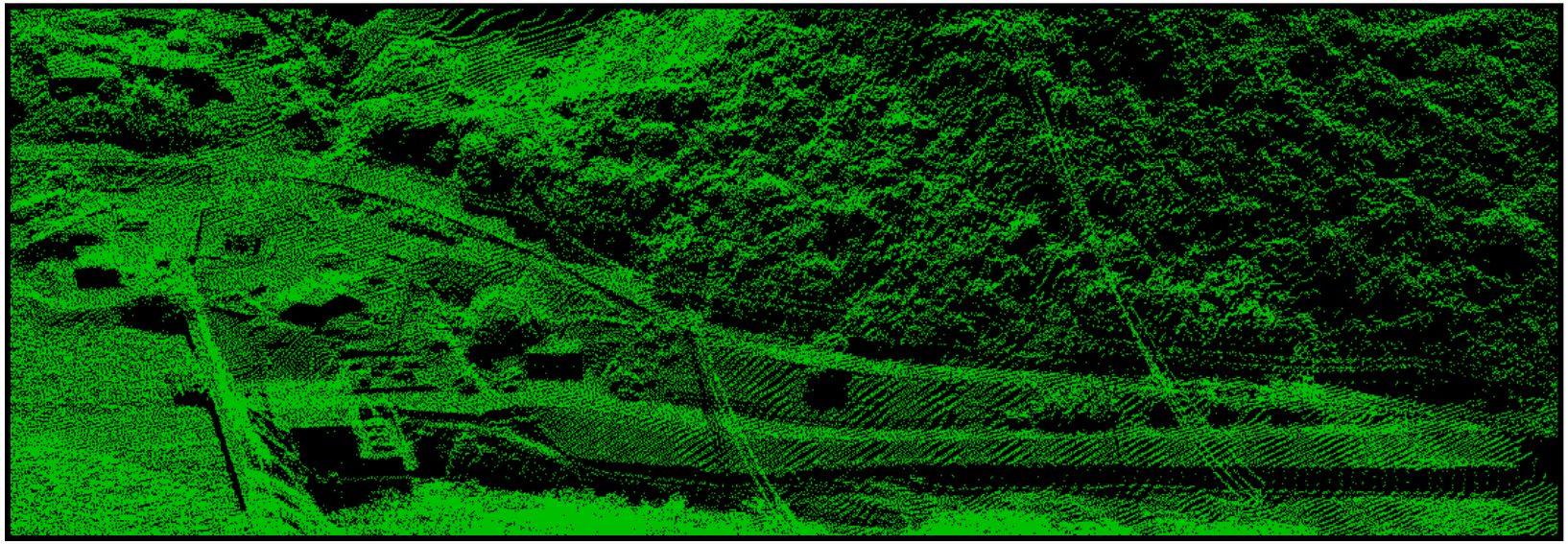


LiDAR Data

- LiDAR is a optional service offering under the contract
- Base product is Quality Level 2 (QL-2) LiDAR collection:
  - 2pts/m^2, 0.7m NPS,
  - Accuracy RMSEZ = 9.25cm,
  - Supports creation of 1-foot contours
  - Includes collection, delivery of calibrated-unclassified point cloud in LAS V1.1 or 1.2 format, intensity images, metadata, pertinent documentation
- Specifications are based largely on USGS Base Spec V1.0
- Spatial reference system is MSPCS, appropriate zone, units of Int'l Feet, most current realization of NAD83, NAVD88 datums
- Options include higher/lower quality levels, classified point cloud, bare earth DEM, hydro flattening, hydro enforcement, LAS V1.4 data format

Base Product LiDAR Raw Point Cloud

- Calibrated-unclassified point cloud
- Contains all collected points, georeferenced, in 3D
- Accurately Adjusted to ground
- Untiled – delivered by swath
- LAS V1.1 or 1.2 format
- Requires software and expertise to exploit



Hydro-electric dam, Puerto Rico

Option: Level of Accuracy
LiDAR Quality Levels

Quality Levels for LiDAR Horizontal Resolution and Vertical Accuracy					
Elevation Quality Levels (QL)	Source	Horizontal Resolution Terms		Vertical Accuracy Terms	
		Point Density	Nominal Pulse Spacing (NPS)	Vertical RMSEz	Equivalent Contour Accuracy
QL 1	LiDAR	8 pts/m_2	0.35 m	9.25 cm	1-ft
QL 2	LiDAR	2 pts/m_2	0.7 m	9.25 cm	1-ft
QL 3	LiDAR	1 – 0.25 pts/m_2	1 – 2 m	≤18.5 cm	2-ft

LiDAR – The Intensity Image

Standard Deliverable under the LiDAR Option

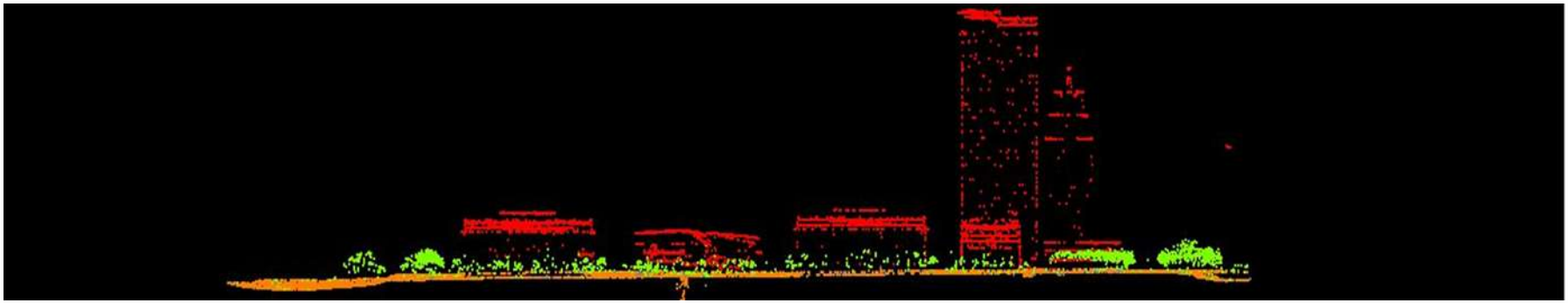
- Each LiDAR return has an intensity value
- Intensity image is a collective display of the intensity values.
- White areas show high reflectance (strong return) while black areas show low reflectance (weak return).
- Useful for:
  - Quality controlling LiDAR
  - Breakline extraction
  - LiDARgrammetry
  - Feature Extraction
- Tiled, 8-bit GeoTIFF

LiDAR - The Classified Point Cloud

Data Upgrade under the LiDAR Option

- Classification process separates LiDAR points into different categories
- Objective for Michigan project is mainly to separate ground points from non-ground points to create a bare-earth surface
- Tiled product deliverable
- LAS V1.1 or 1.2 format

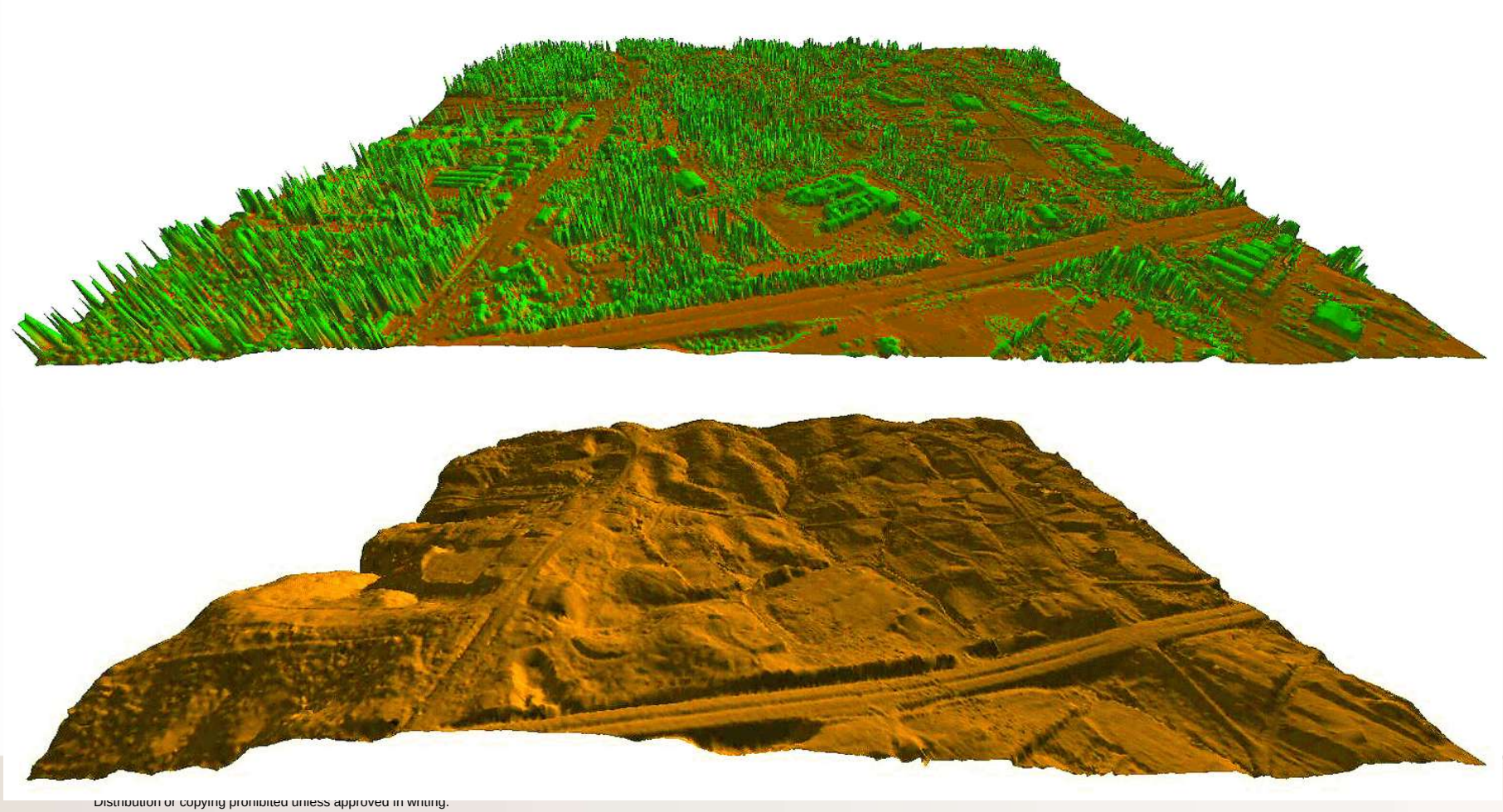
Minimum Classified Point Cloud Classification Scheme	
Code	**Description**
1	Not ground (all returns deemed not ground returns)
2	Bare-earth ground (DEM)
7*	Noise (low or high; manually identified if needed)
9	Water (if Hydro-flattened or Hydro-enforced DEM requested)
10**	Ignored Ground (if Hydro-flattened or Hydro-enforced DEM requested; Breakline proximity)
11	Withheld (if the Withheld bit is not implemented in processing software)



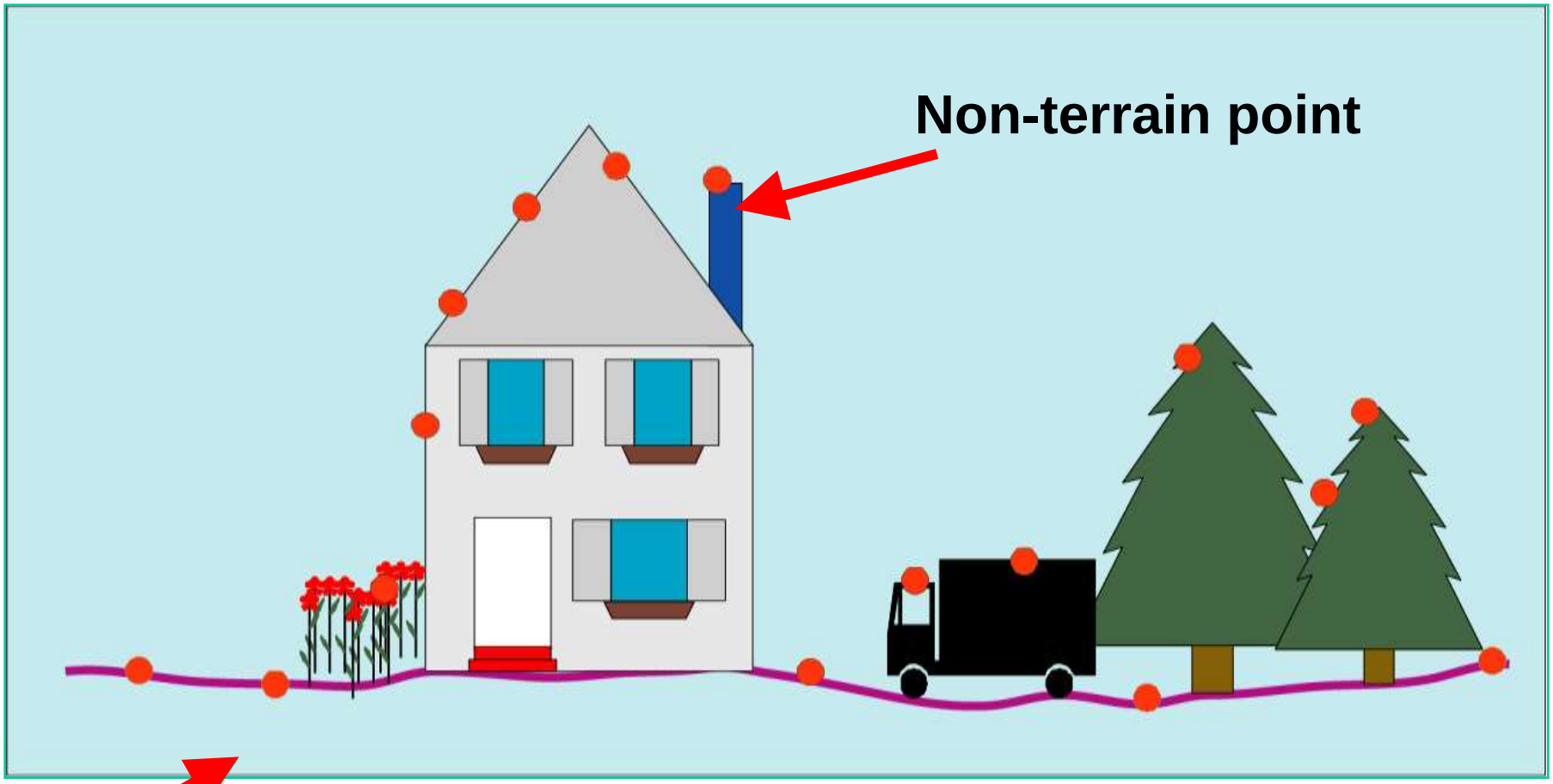
DTM/DSM Extraction Processing

SANBORN

- Standard methods: filtering and thinning



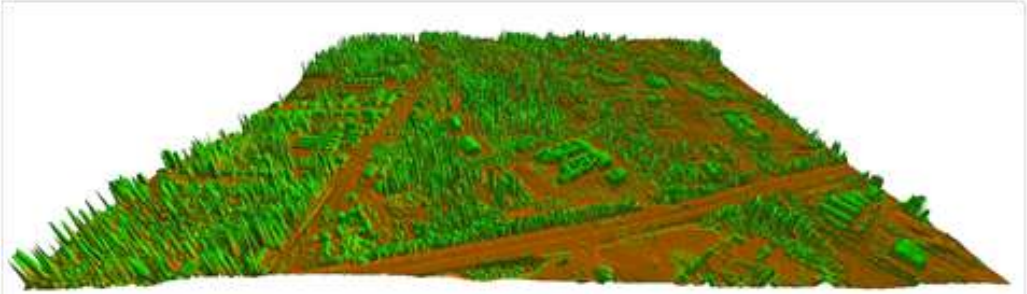
Digital Surface Model (DSM)



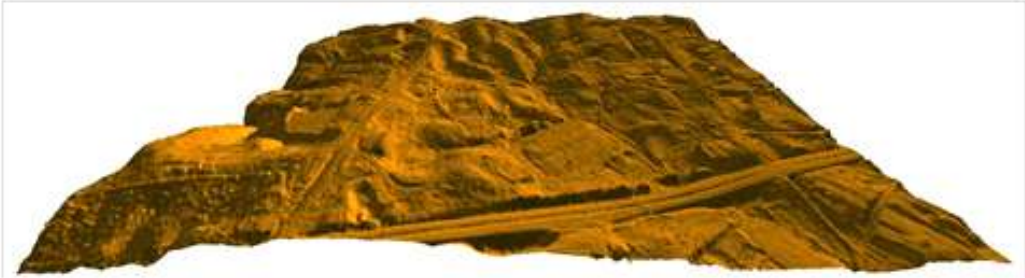
LiDAR – The Bare Earth Surface DEM

Specification: Data Upgrade under the LiDAR Option

- Bare earth surface DEM contains ground points only – 90-95% removal of other features
- ASCII point file with grid spacing no greater than 3-feet, no less than nominal pulse spacing
- Raster data file in ERDAS .IMG format with grid spacing no greater than 3-feet, no less than nominal pulse spacing
- Tiled delivery



Classified Data – All Ground & Non-Ground



Bare Earth Surface

LiDAR – Hydro Flattened & Enforced DEM's

Data Upgrade under the LiDAR Option

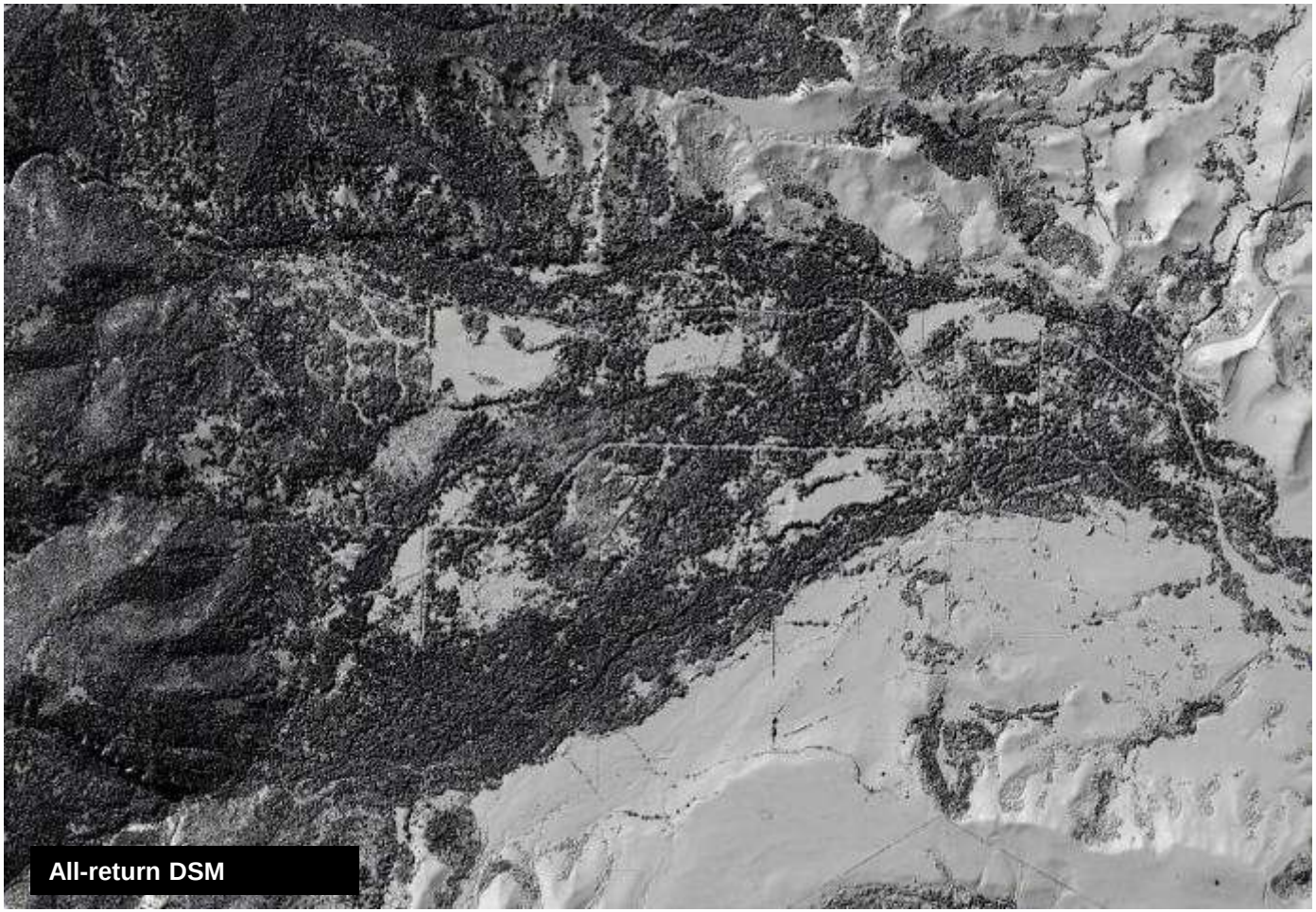
- Deliverables for hydro-flattened or enforced DEM's include:
  - ✓ ASCII point file with grid spacing no greater than 3-feet, no less than nominal pulse spacing
  - ✓ Breakline data in Esri shapefile or geodatabase format
  - ✓ Raster data file in ERDAS .IMG format with grid spacing no greater than 3-feet, no less than nominal pulse spacing
  - ✓ Tiled delivery
- Note that State of Michigan specifications contain some departures from USGS Base Spec V1.0.

LiDAR – Hydro Flattened & Enforced DEM's

Data Upgrade under the LiDAR Option

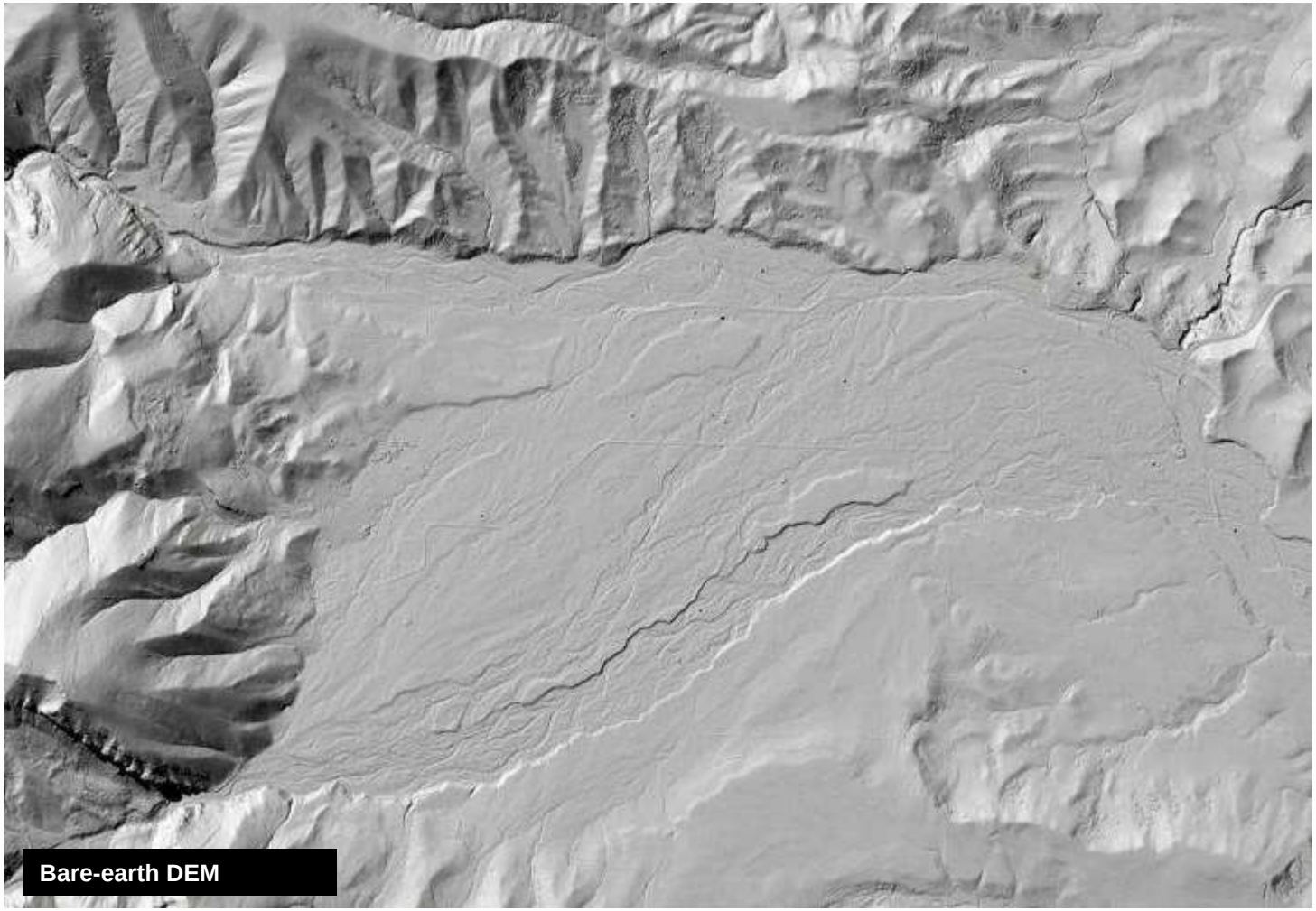
- **Hydrological Flattening** - Processing of a DEM so you have a uniform, continuous water surface. Water bodies >2 acres, streams wider than 100 feet.
- **Hydrological Conditioning** - Processing of mapped water bodies so that lakes and reservoirs are level and so that streams flow downhill

Raw Point Cloud (All-Returns)

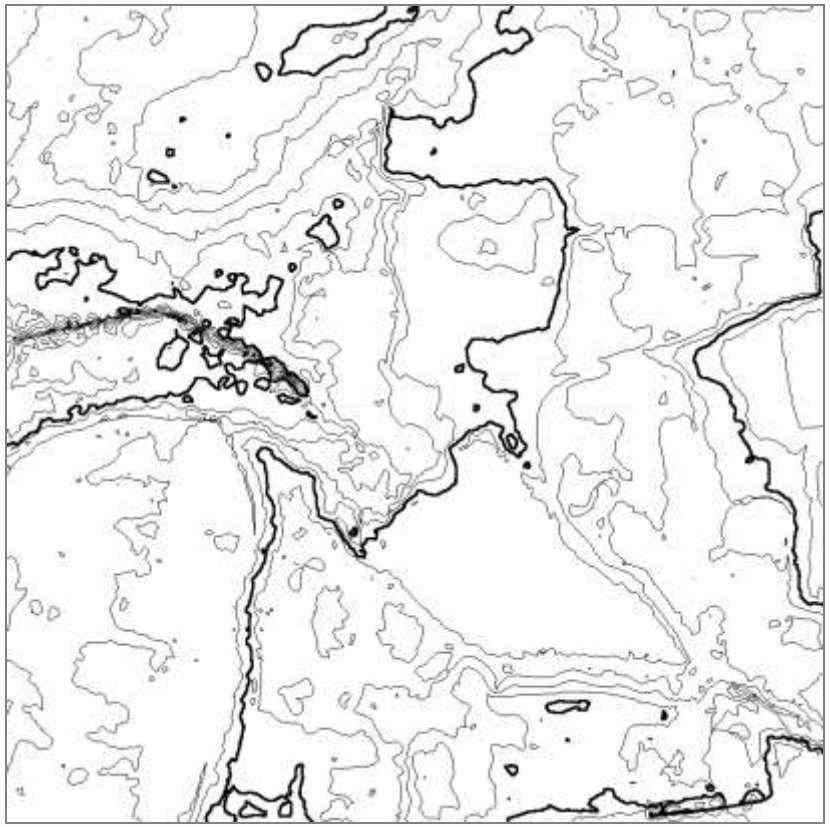


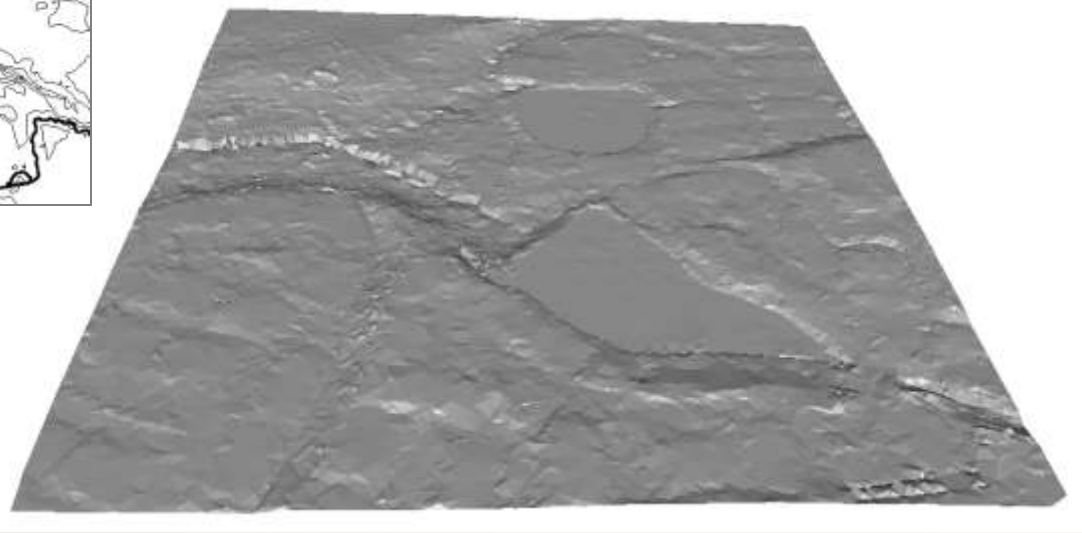
LiDAR: Bare-earth DEM

Story, Wyoming



Hydro-flattening/Contouring

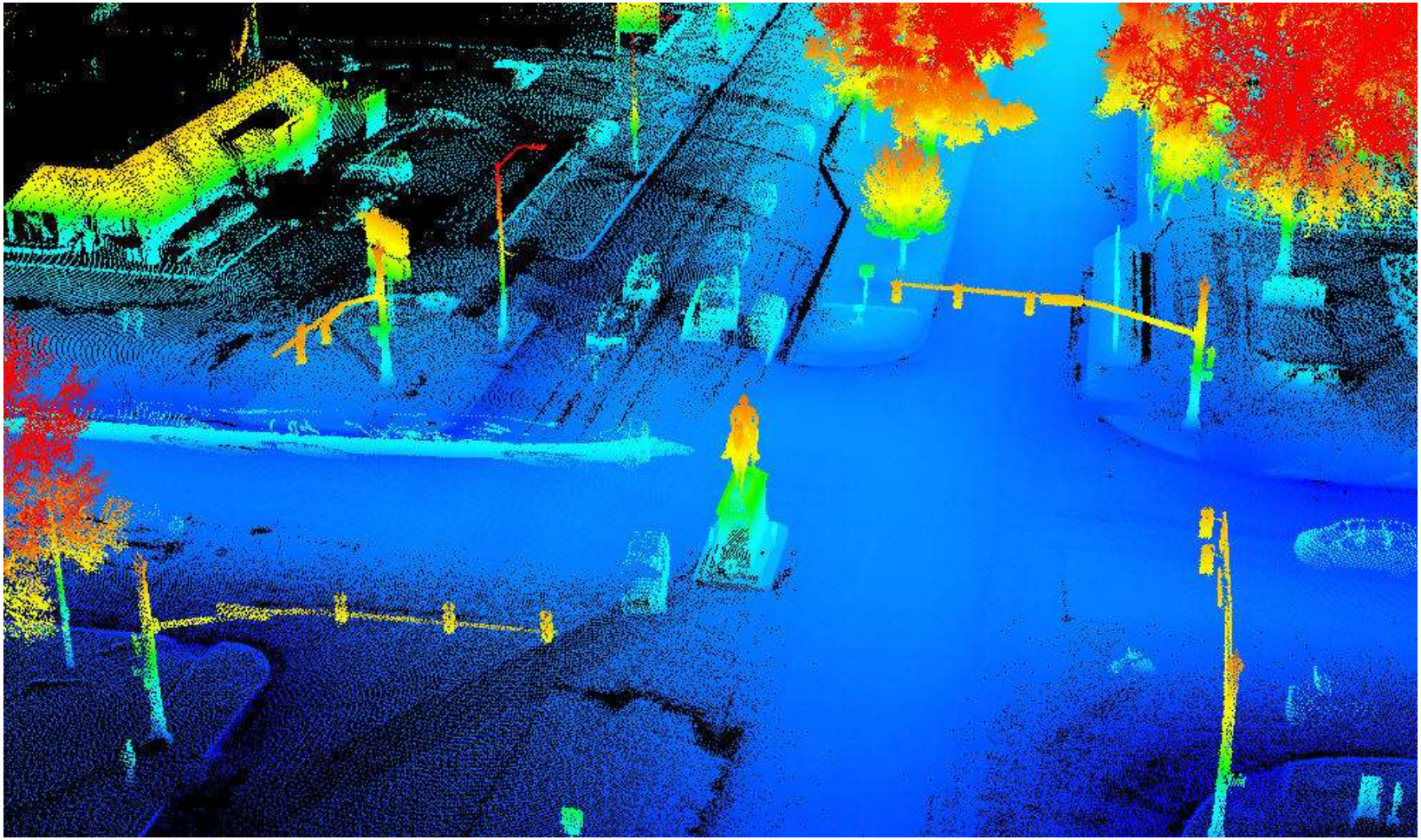




DEM, DTM, DSM

- DEM: Digital Elevation Model
  - A data structure made up of x, y points with z-values representing elevations
  - No breaklines, mass points only
  - Typically Gridded
- DTM: Digital Terrain Model
  - A data structure made up of x, y points with z-values representing elevations
  - Bridge removal
  - DEM + breaklines = DTM
- DSM: Digital Surface Model
  - A model that includes features above ground (buildings and vegetation)
  - Combine with DTM/DEM for all coverage

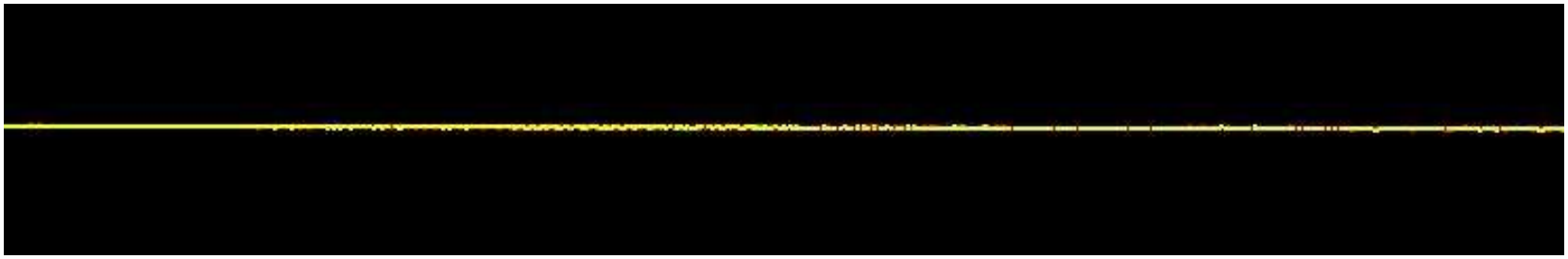
LiDAR Processes



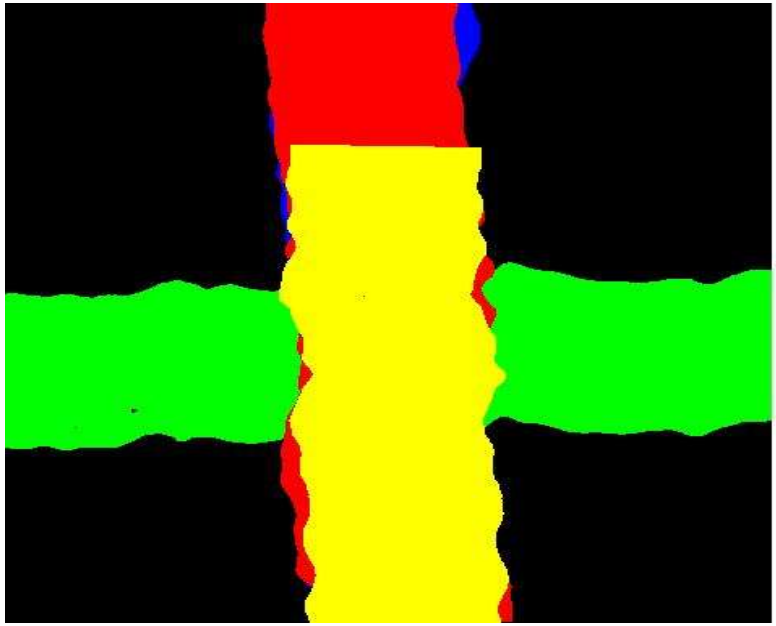
LiDAR Calibration

Critical

- Separate sensor collection versus check point survey



- Calibration at installation
- Calibration every three months
- Calibration every mission
- Proper installation and lever Arm survey



Four Runway Calibration Scans

Acquisition 24/7

Cleaning the Optical Glass under the aircraft

DTM/DSM Extraction Processing

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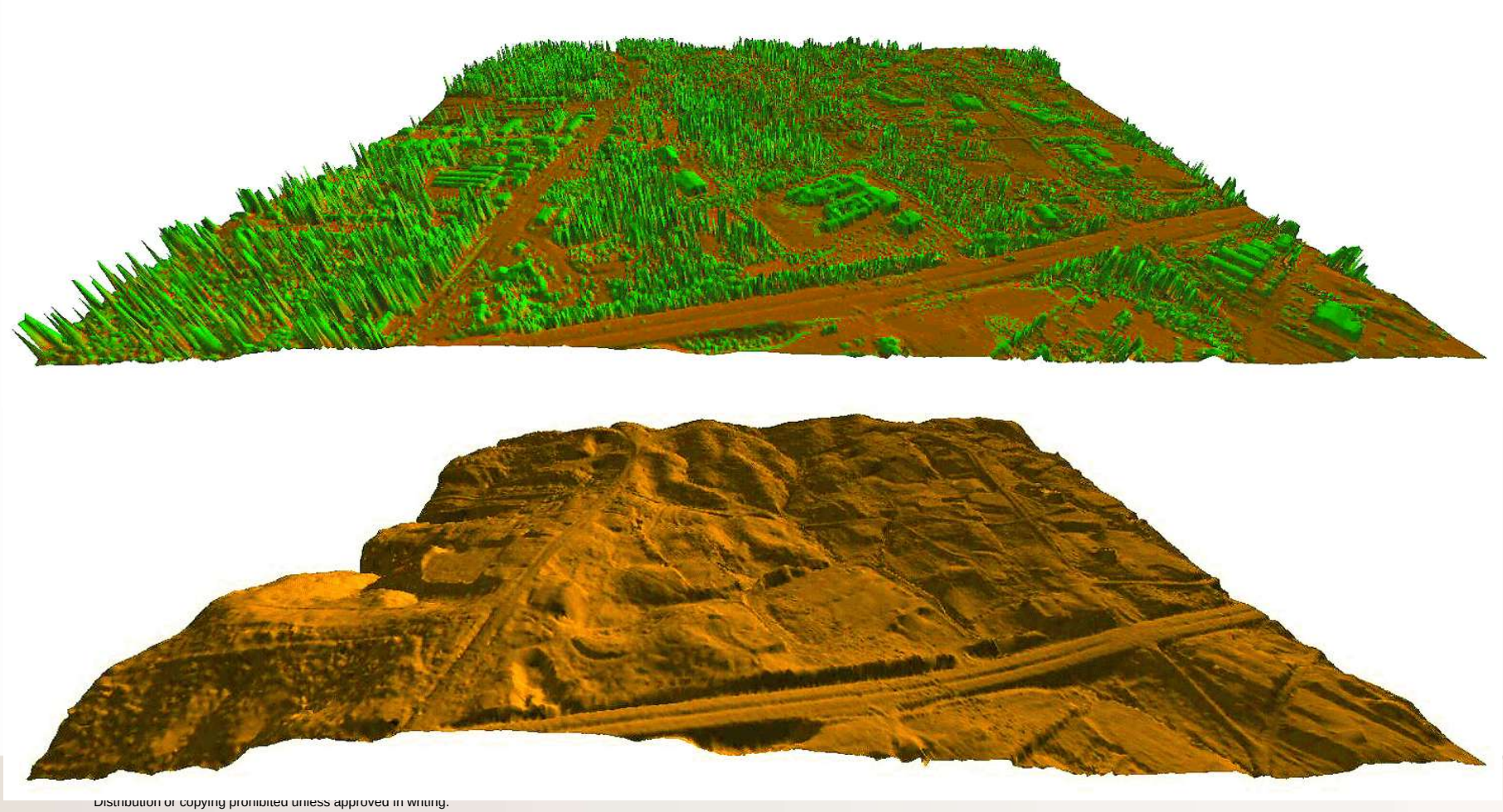
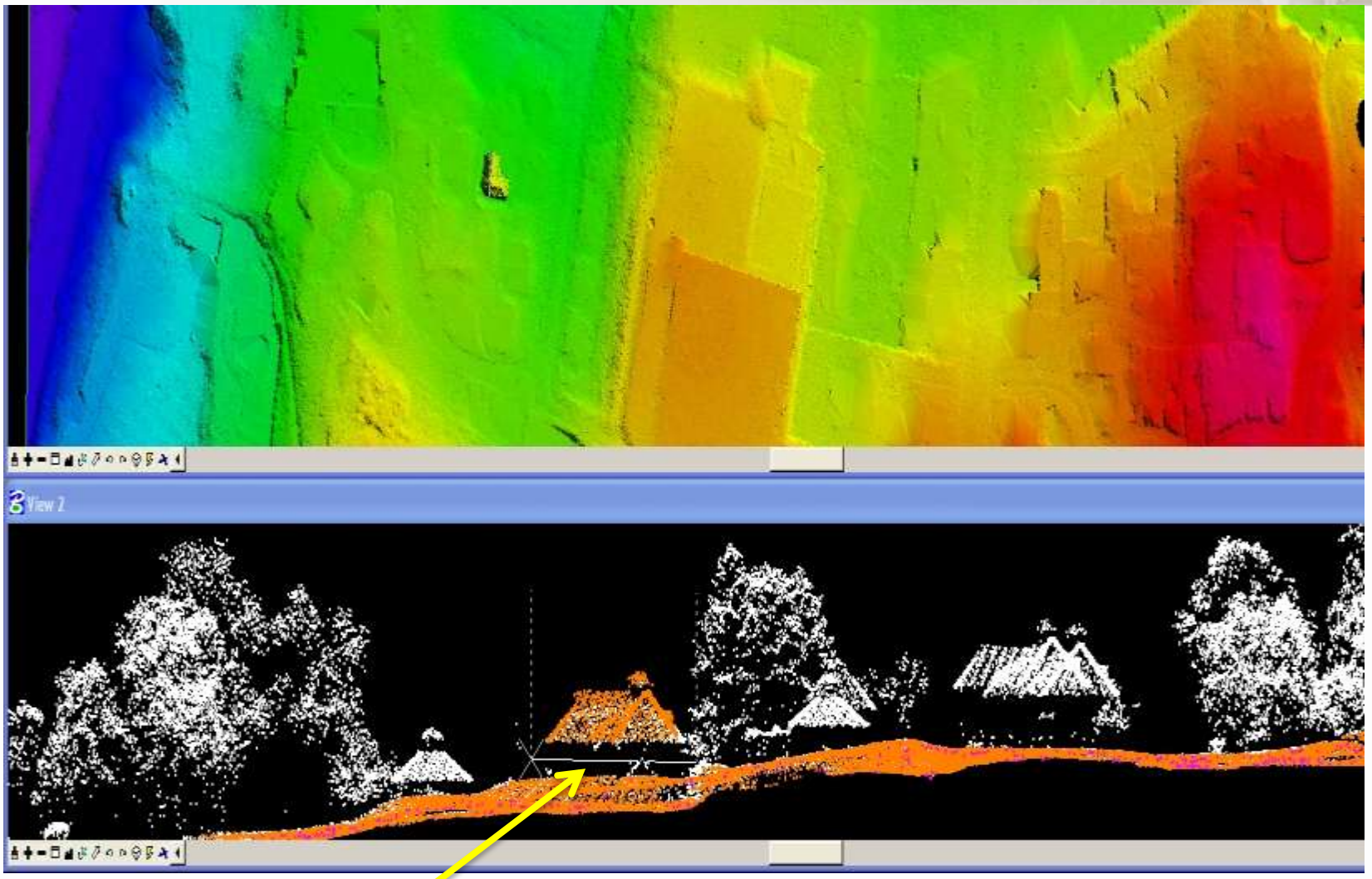
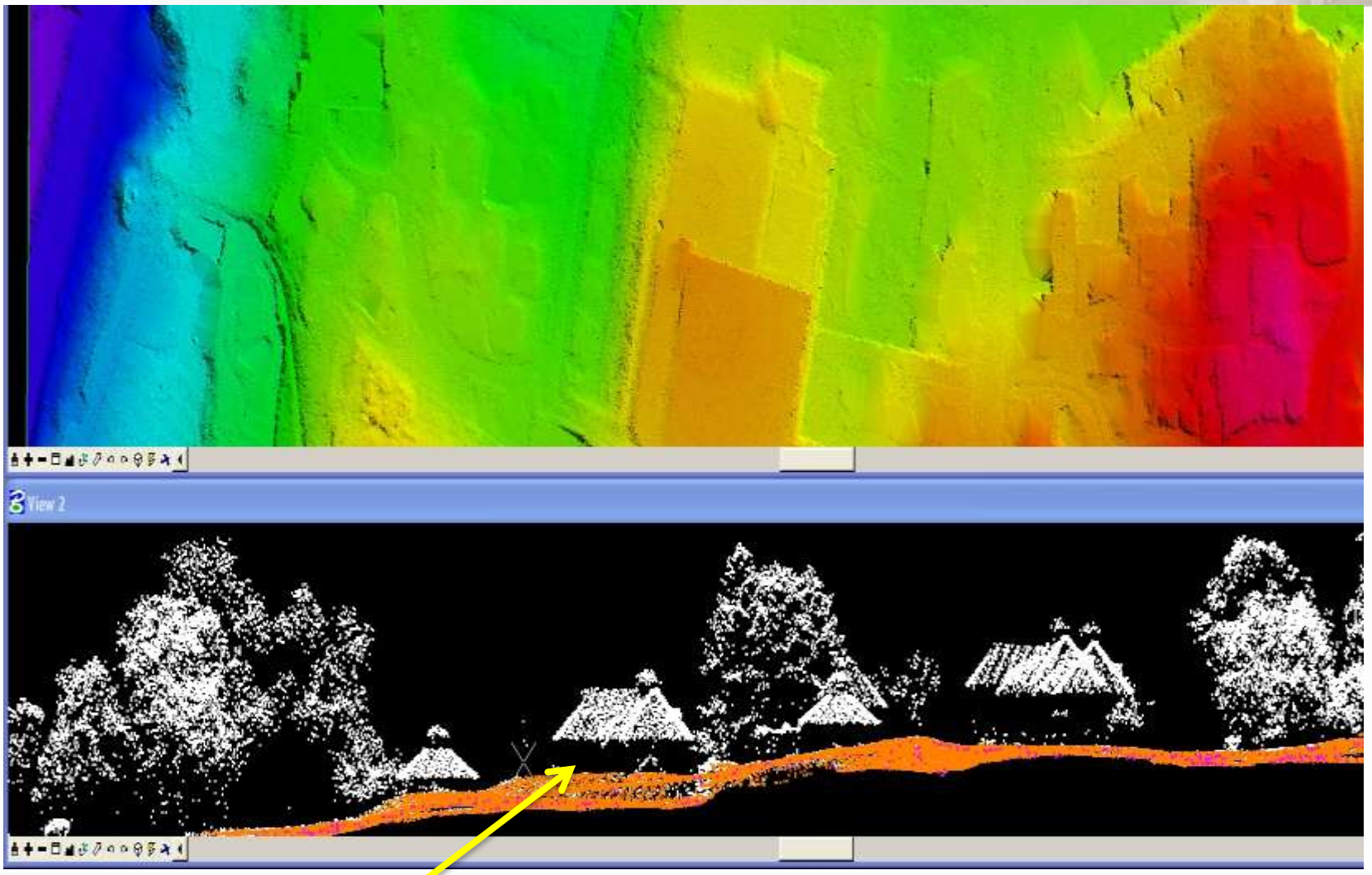
- Standard methods: filtering and thinning



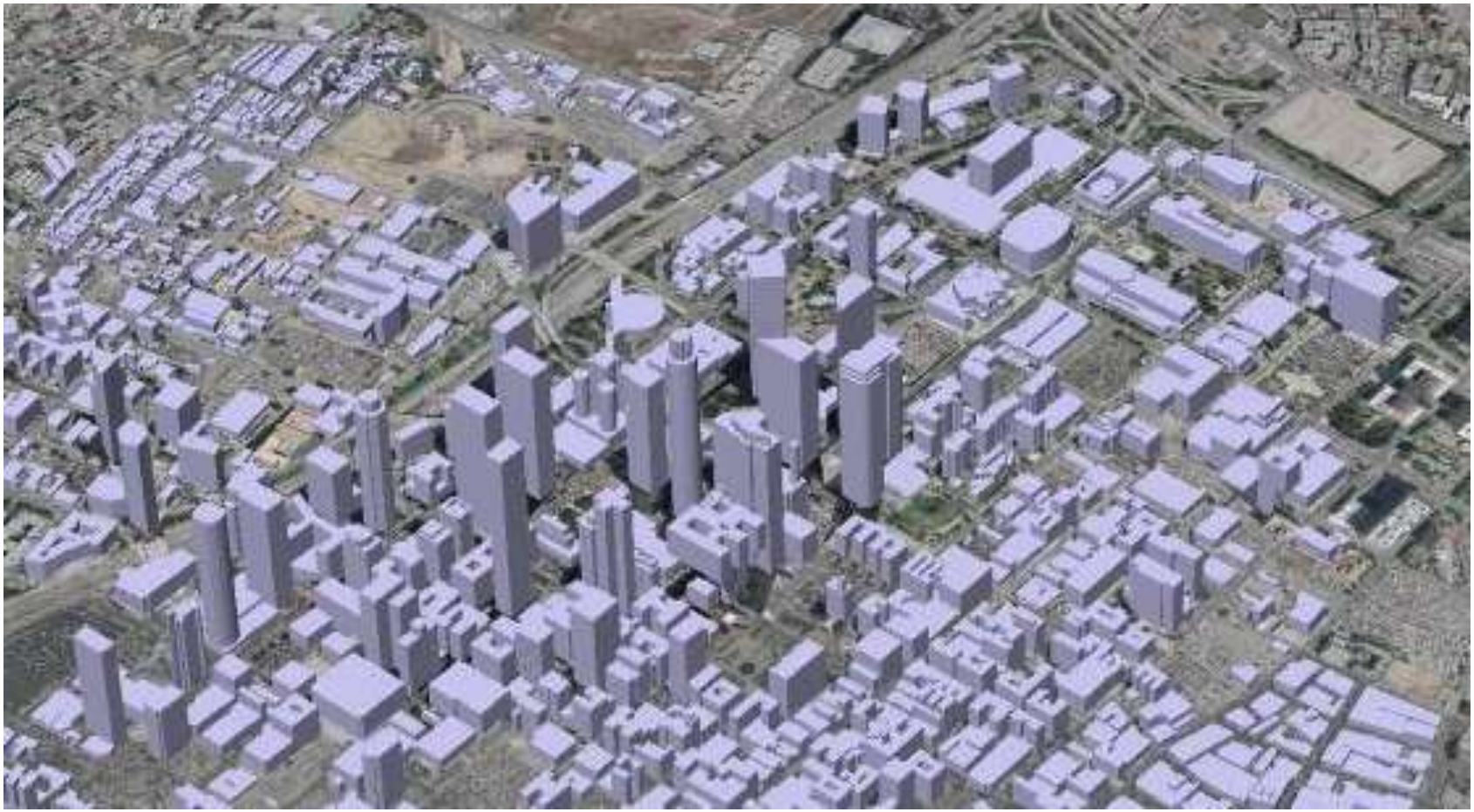
Manual Editing



Final Manual Edit & QC

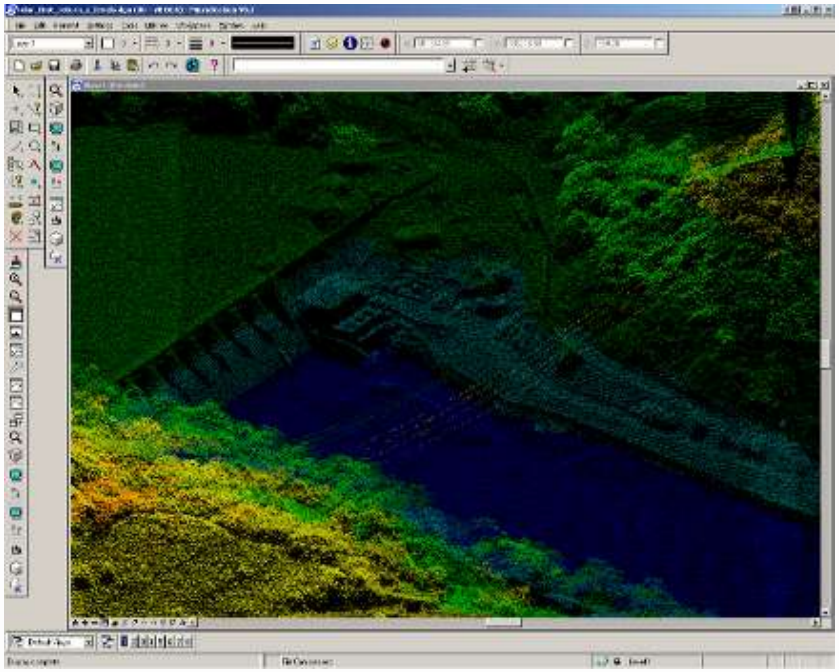


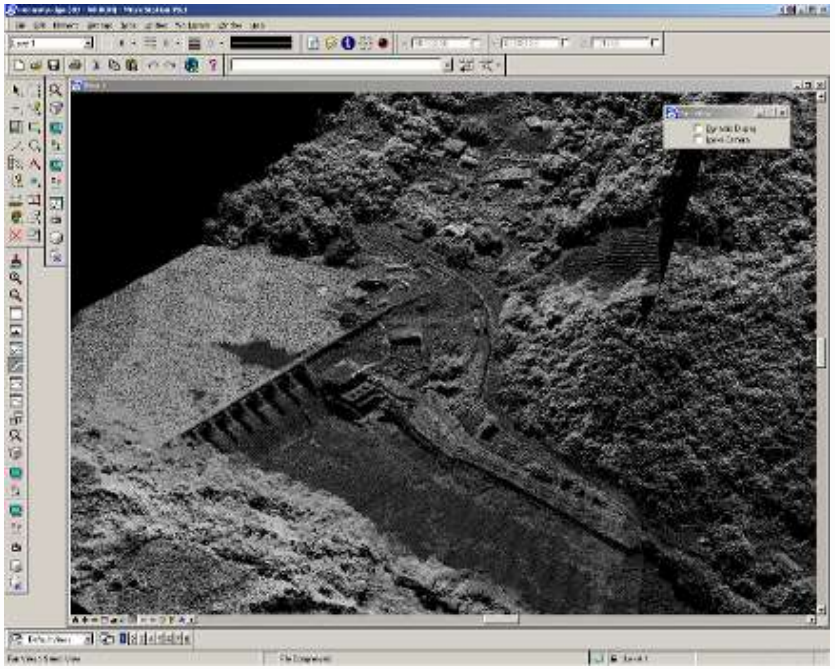
Application Trends for LiDAR



Applications

Oblique Views

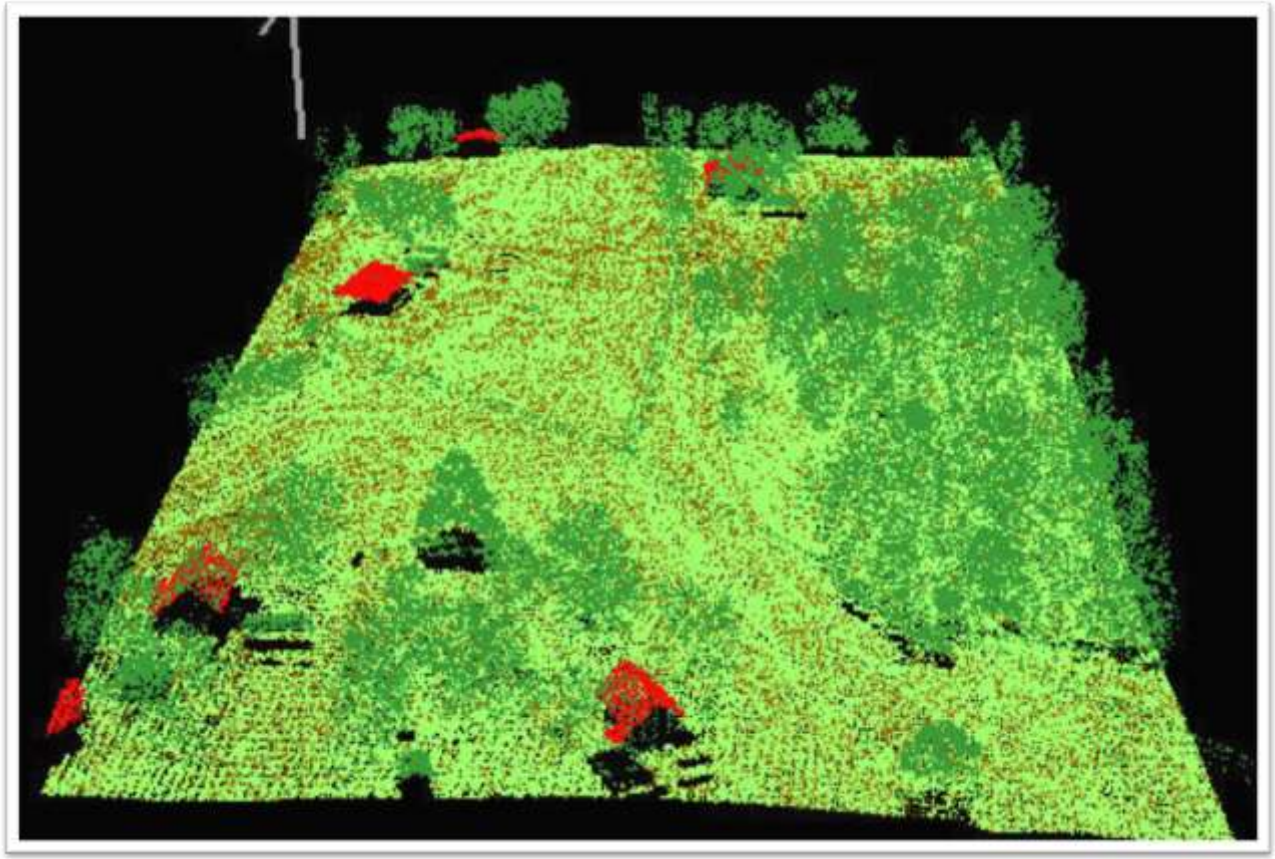




Hydro-electric Dam, Puerto Rico

Applications LiDAR – Fully Classified Data

- Buildings
- Bare Earth
- Vegetation



Application Trends for LiDAR

Building Extraction

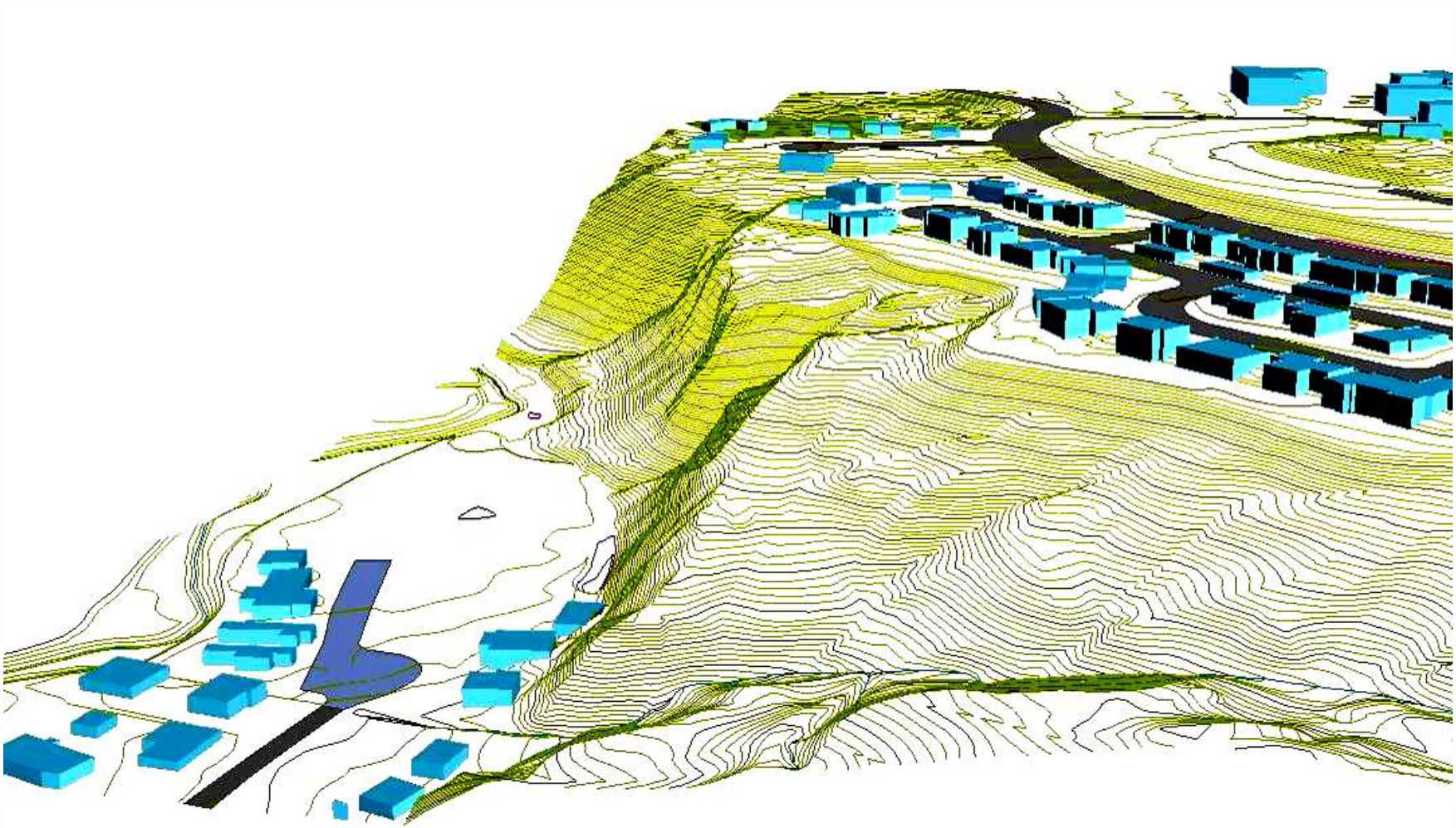
Morris County, NJ

Digital Surface Model

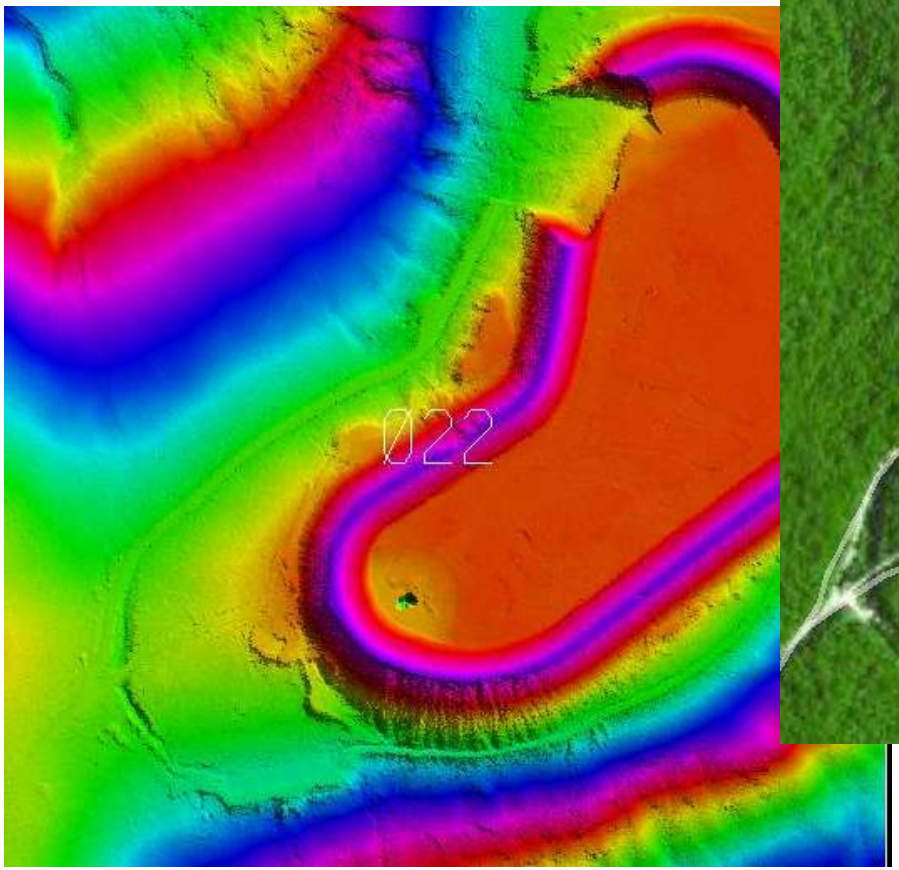
Building Footprints

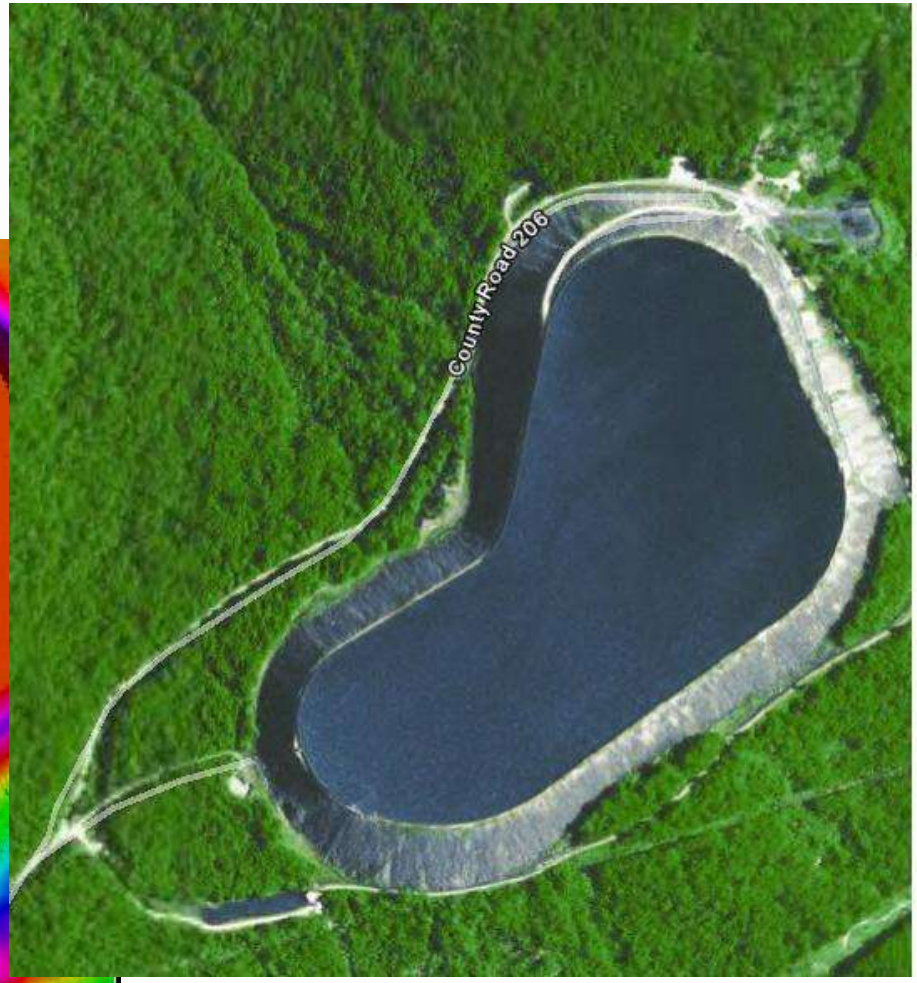
Application Trends for LiDAR

Simple Building Outline: 2D Polygon with Elevation Attribute



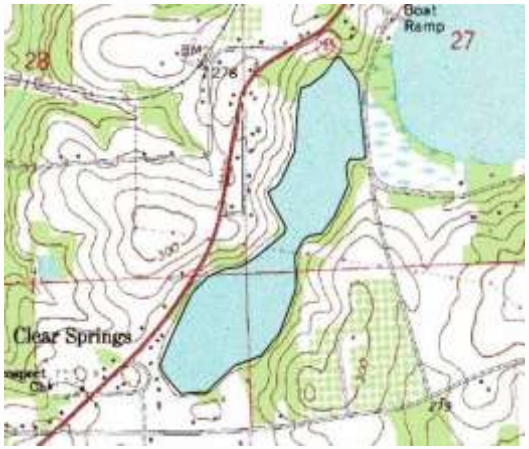
Tom Sauk Reservoir; Rapid Response



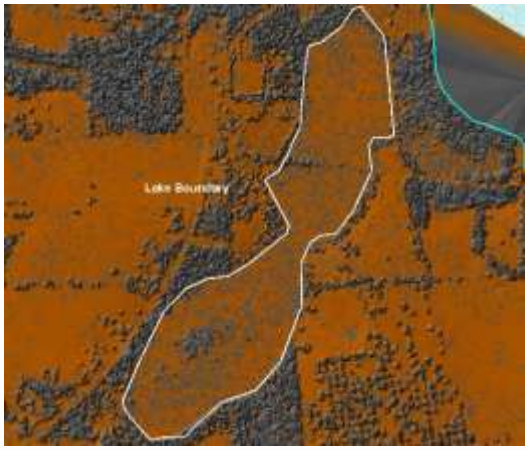


Application Trends for LiDAR

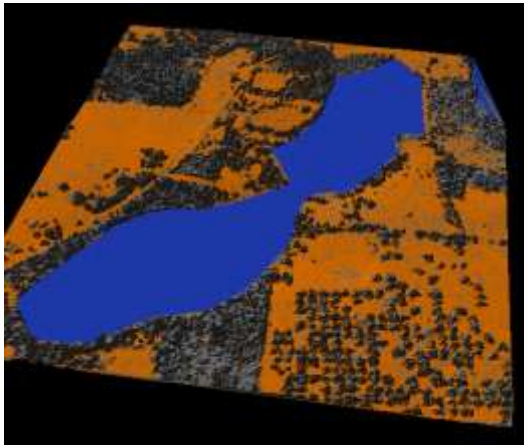
Water Body Classification



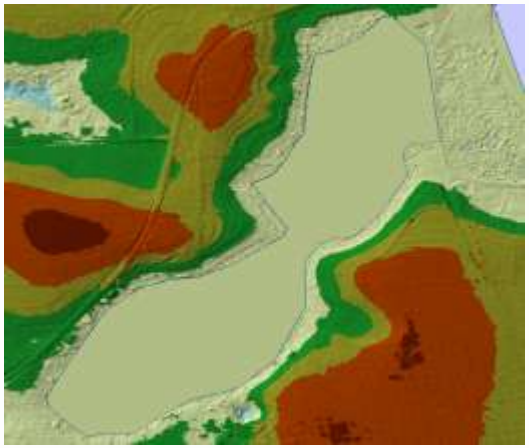
Lake on map



Lake before classification and elevation averaging

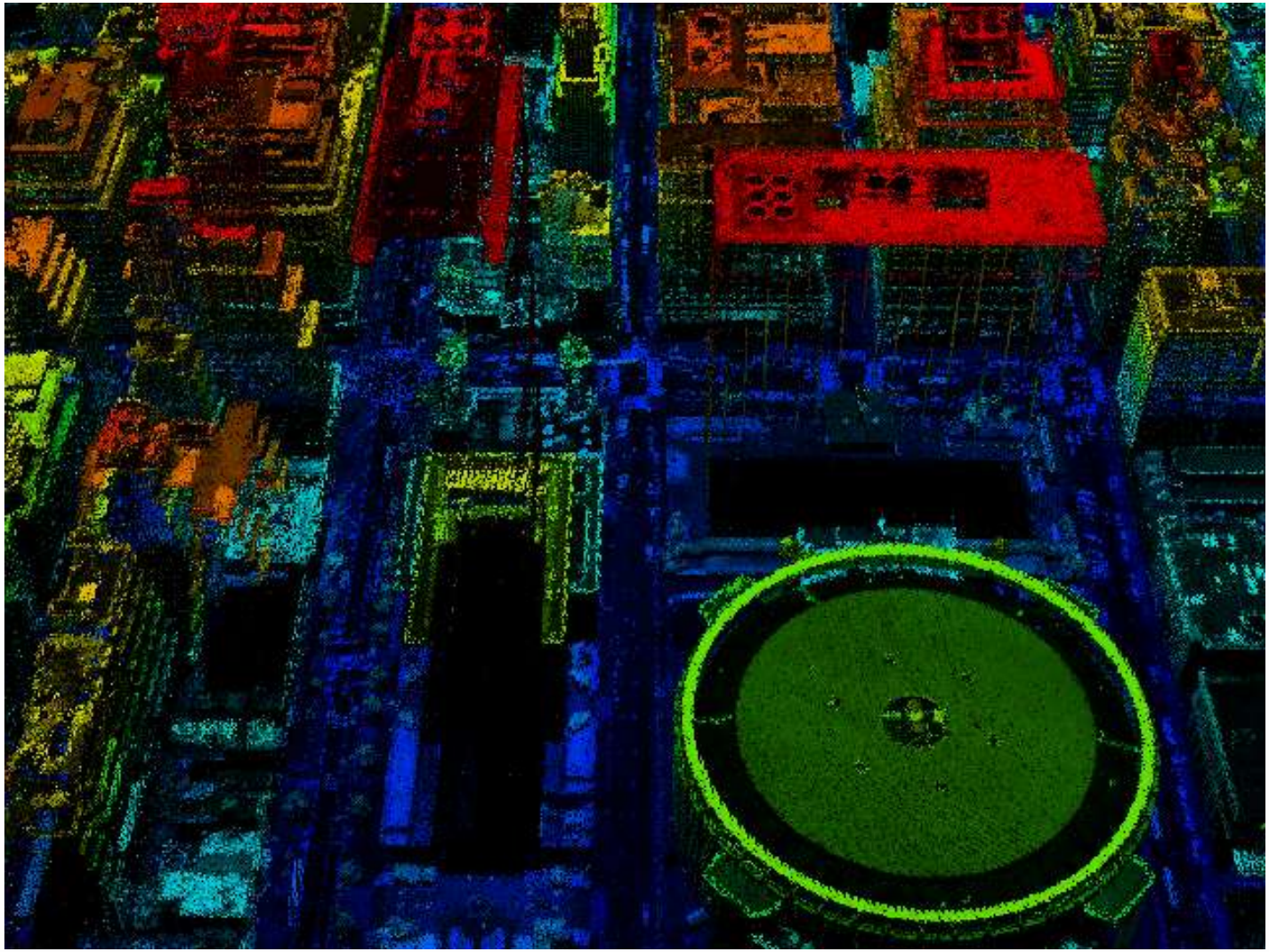


Lake after classification and elevation averaging



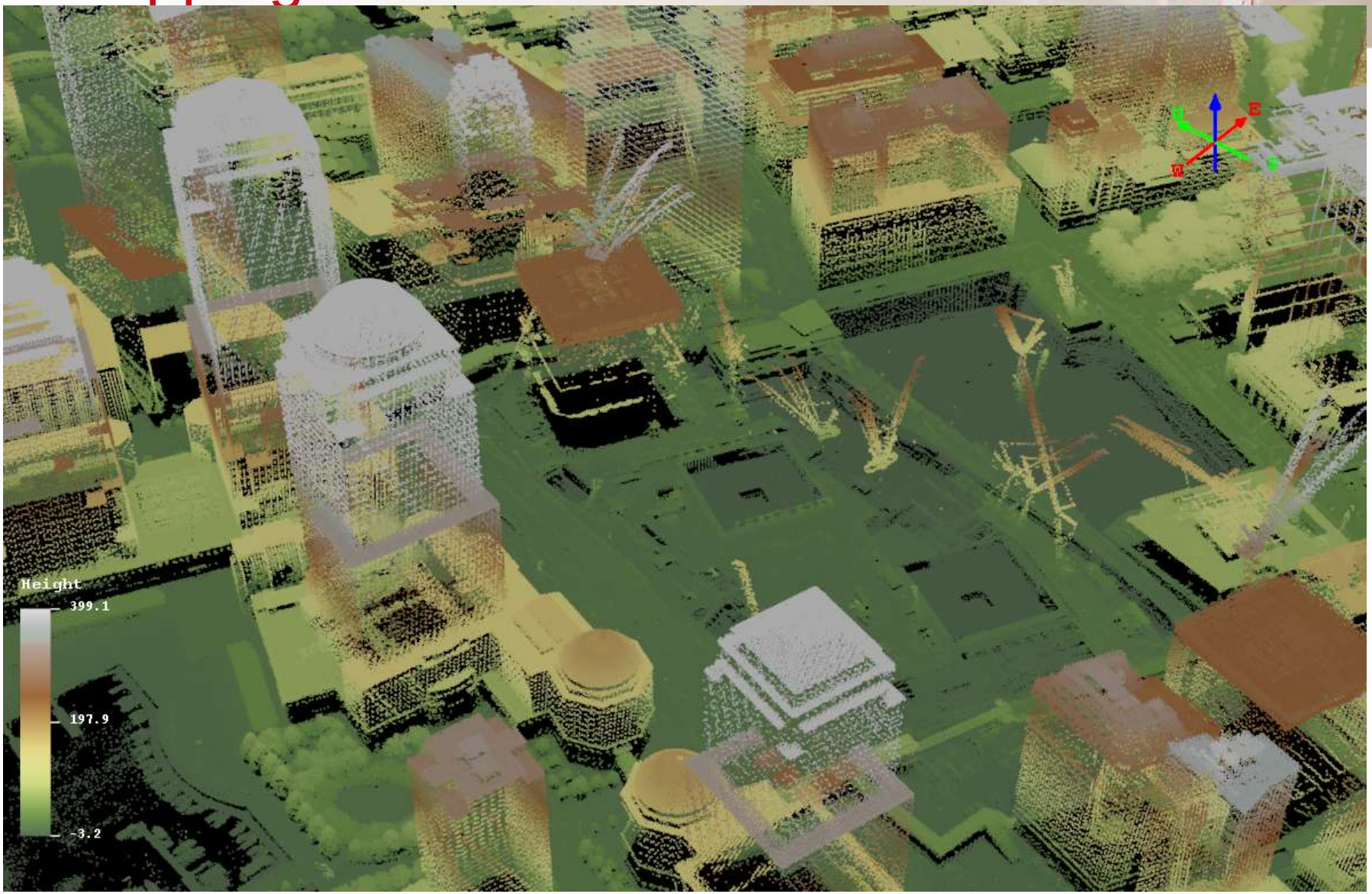
ArcTIN surface model

Mapping Solar Insolation



Mapping Solar Insolation

SANBORN



Michigan – DaaS (Option)

- Imagery hosted in the ‘Cloud’
- State to load and test accessibility and performance
- Determine what requirements are met
- Assess viability and cost of implementing additional requirements
- Test and determine course of action
- Possible offering to partners

Imagery Pricing

Imagery Partnership Pricing
January 30, 2013

SANBORN

$28 per square mile for base product:

- 12” GSD
- 4-band
- AOIs defined by County boundary

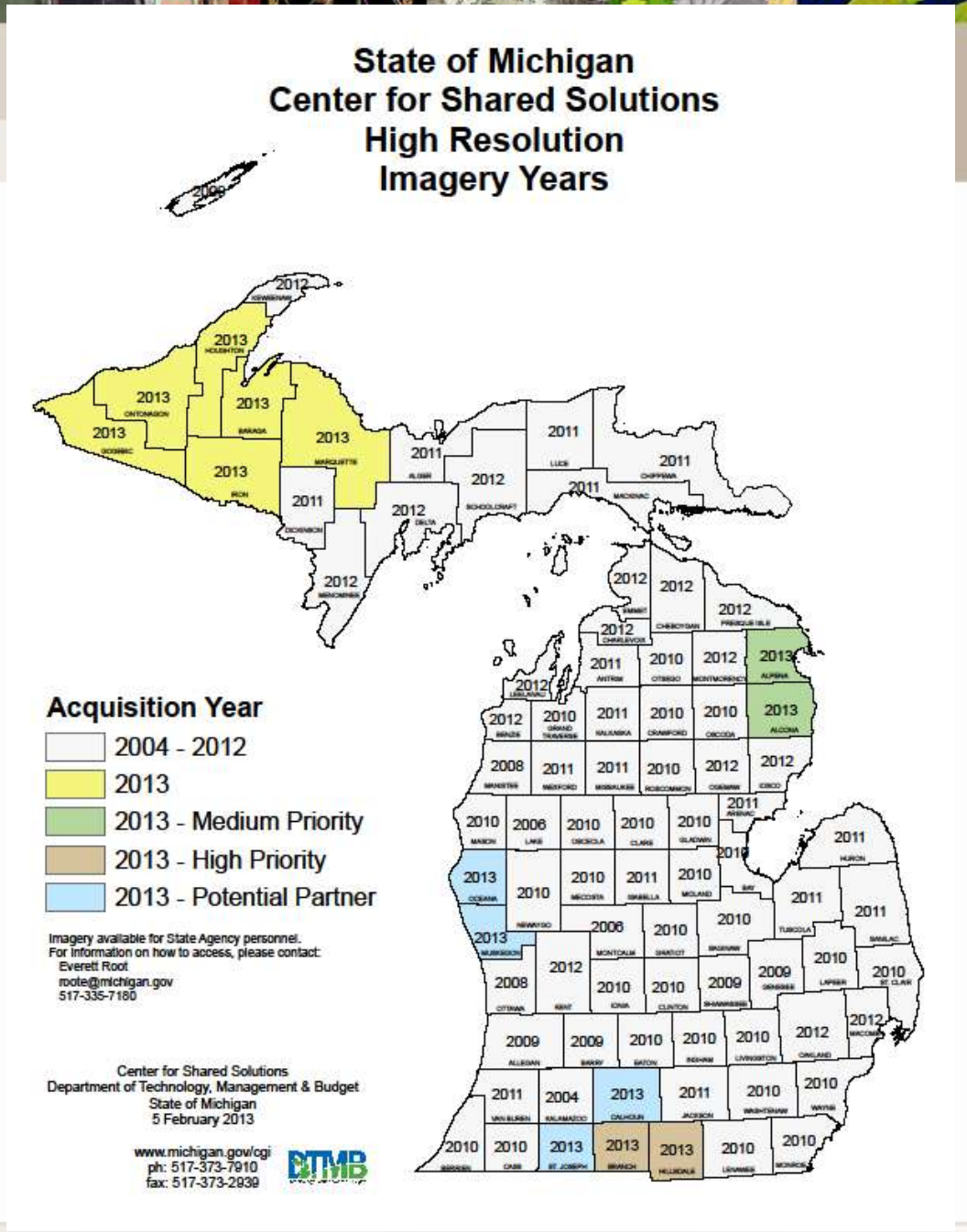
Detailed specifications in Ortho-Imagery Specifications SOM_CSS.doc

Percent Price Reduction for contiguous AOIs – assumes consistent GSD collection over the AOI	
Contiguous Square Miles	Price Reduction
0 – 2,500	0%
2,501 – 5,000	16.00%
>5,000	17.70%
BUY UPS – Price in addition to base product cost of $28 / sq. mile	
6” GSD, 4-band, per square mile price based on the following High Resolution Areas (HRA) values. Detailed specifications in Ortho - Imagery Specifications SOM_CSS.doc - Section 6.1	
Square Miles	Cost per sq. mile
10-100	$151.44
101-500	$94.08
>500	$82.53
3” GSD, 4-band, per square mile price based on the following High Resolution Areas (HRA) values. Detailed specifications in Ortho - Imagery Specifications SOM_CSS.doc - Section 6.1	
Square Miles	Cost per sq. mile
10-100	$359.14
101-500	$243.57
>500	$226.87
Updated DEM, per square mile price to be based on AOI. Detailed specifications in Ortho - Imagery Specifications SOM_CSS.doc - Section 6.2	
AOI	Cost per sq. mile
Equal to AOI	Included in Ortho Prices
Compressed Image Mosaics - price per County. Detailed specification in Ortho - Imagery Specifications SOM_CSS.doc - Section 6.3	
Cost / County	
$400	

2013 Tentative Flight Areas

COUNTY	SQ MILES	PARTNER COST	PARTNER TOTAL
ST JOSEPH (partner)	521	28.00	$14,588
CALHOUN (partner)	718	28.00	$20,104
BRANCH	520		
HILLSDALE	607		
TOTAL	2366		

COUNTY	SQ MILES	PARTNER COST	PARTNER TOTAL	SAVINGS
ST JOSEPH (partner)	521	23.52	$12,254	$2,334
CALHOUN (partner)	718	23.52	$16,887	$3,217
BRANCH	520			
HILLSDALE	607			
KALAMAZOO	580			
	2946			



Lidar Pricing

LIDAR PRICING
January 30, 2013

Base product collected using specifications defined in Sections 4, 5, and 6 of *Lidar Specifications SOM_CSS.doc* and QL 2 accuracy specifications from Section 4.7 (pg. 5)
**** Note:** The total cost for any deliverable is dependent on the Base Product Cost plus the deliverables that precede that deliverable.
For example: Cost of Bare-Earth Surface (option 2) data would equal Base Product cost + Option 1 cost + Option 2 cost for the chosen Area Of Interest (AOI)

Base Product Deliverable

Raw Point Cloud - Calibrated-unclassified -- see Deliverables Section 7.2

square miles	Cost per sq. mile	% Increase for QL 1	% Reduction for QL 3
<100	$248.17	132%	8%
101-500	$129.31	160%	55%
501-1000	$122.25	162%	55%
1001-5000	$107.19	167%	55%
>5000	$99.44	206%	64%

Deliverable Option 1

Classified Point Cloud -- see Deliverables Section 7.3

square miles	Cost per sq. mile	% Increase for QL 1	% Reduction for QL 3
<100	$30.03	107%	28%
101-500	$27.02	108%	36%
501-1000	$26.51	108%	36%
1001-5000	$26.13	108%	36%
>5000	$26.06	109%	36%

Deliverable Option 2

Bare-Earth Surface -- see Deliverables Section 7.4

square miles	Cost per sq. mile	% Increase for QL 1	% Reduction for QL 3
<100	$13.97	0%	0%
101-500	$13.97	0%	0%
501-1000	$13.97	0%	0%
1001-5000	$13.97	0%	0%
>5000	$13.97	0%	0%

Deliverable Option 3

Hydro-flattened Bare-Earth Surface, including Breaklines -- see Deliverables Section 7.5

square miles	Cost per sq. mile	% Increase for QL 1	% Reduction for QL 3
<100	$10.06	0%	0%
101-500	$10.06	0%	0%
501-1000	$10.06	0%	0%
1001-5000	$10.06	0%	0%
>5000	$10.06	0%	0%

Deliverable Option 4

Hydro-Enforced Digital Elevation Model (DEM) -- see Deliverables Section 7.6

square miles	Cost per sq. mile	% Increase for QL 1	% Reduction for QL 3
<100	$63.96	0%	0%
101-500	$35.12	0%	0%
501-1000	$29.25	0%	0%
1001-5000	$29.25	0%	0%
>5000	$29.25	0%	0%

Deliverable Option 5

Lidar Intensity Images -- see Deliverables Section 7.7

square miles	Cost per sq. mile	% Increase for QL 1	% Reduction for QL 3
<100	0	0%	0%
101-500	0	0%	0%
501-1000	0	0%	0%
1001-5000	0	0%	0%
>5000	0	0%	0%

Lidar Pricing

OPTION	TOTAL @ 600 SQ. MILES
Base Product (BP)	$73,350
BP + Option #1	$89,256
BP + Option #1 + #2	$97,638
BP + Option #1 + #2 +#3	$103,674
BP + All Options	$121,224

OPTION	TOTAL @ 36 SQ. MILES
Base Product (BP)	$8,934
BP + Option #1	$10,015
BP + Option #1 + #2	$10,518
BP + Option #1 + #2 +#3	$10,880
BP + All Options	$13,182

How to Order

- Work with Everett (rootе@michigan.gov)
  - 517-373-7910
- Create Statement of Work (SOW)
  - Identify products
  - Calculate costs
  - Identify partner points of contact
- Implement agreement (still in draft)
  - Partner signatures, Board approvals, etc.

Thank you to State of Michigan for this Opportunity

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